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# SVIC NOTES

## PUBLICATION ANNOUNCEMENT

We are proud to announce a new SVIC special publication, "The Environmental Qualification Specification as a Technical Management Tool" by Dr. Charles T. Morrow.\*

Environmental qualification specifications prescribe shock and vibration conditions for use in test at the end of development as a verification of design adequacy. Such specifications can also serve as technical management tools during the development process. This report is a study of the effectiveness of qualification specifications in this technical management role and of a means for improving this effectiveness. It is intended for any reader, administrative or technical, who influences initial decisions concerning shock and vibration approaches, or the specifications and accepted practices underlying such decision.

This work started out as an evaluation of shock and vibration specifications in the more restricted area of design of isolation systems and shipping containers. It was later broadened in scope to include the usage of environmental qualification specifications in all shock and vibration areas. It is the first survey ever carried out to evaluate environmental qualification specifications as technical management tools.

Chapter 1 is an introduction and description of the study. Chapters 2 and 3 discuss the decision process related specifically to specifications applicable to packaging and isolation, based largely on a survey conducted in these areas. Chapter 4 offers some recommendations for change to improve the cost/effectiveness ratio with respect to isolation and packaging development problems. By far the most important part of this report is Chapter 5, which contains some recommended changes in MIL-STD-810 and related specifications to improve the cost/effectiveness of shock and vibration engineering more generally. The body of the publication is supported by appropriate appendices.

J.G.S.

\* Order from: The Shock and Vibration Information Center, Code 5804, Naval Research Laboratory, Washington, DC 20375; Price: \$12.00 (U.S. and Canada); \$15.00 (Foreign)

# EDITORS RATTLE SPACE

## MINI MONOGRAPHS FOR LITERATURE DISTILLATION

In a recent editorial on distillation of the literature I noted the increased volume of literature on new technology and discussed the lack of distillation of this literature in articles, books, and monographs. Even though excellent new books are regularly being published, most of them are not touched after they are deposited in our archives. Essentially this means that the research and writing efforts expended to develop these publications is wasted. Chances are that the work will be repeated by another investigator - thus adding to inefficiency and repetition in the literature. Although review and survey articles help to eliminate this problem, they do not bring the technology to the designer, developer, or experimentalist in the detail required to solve problems.

Detailed distillations of limited areas of the literature would be of use to many engineers. Many articles of this type now appear as mini monographs in our growing number of trade magazines. These articles provide practical information on narrow subject areas. In some cases series of such published articles are bound into a monograph, which thus becomes a book, or the beginning of one.

In the DIGEST we publish feature articles that can be a basic tutorial, a discussion of a new technological area, or an in-depth report of a procedure, technique, or object. The feature article also provides a forum for the *mini monographs* mentioned above. Mini monographs on test procedures, design and computational technique, physical data, and diagnostic techniques would be of value to many engineers. The writer of an article of this nature is always recognized. If you are interested in writing such an article or series of articles, please contact me.

R.L.E.

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## ACOUSTIC IMPEDANCE MEASUREMENT METHODS

R. Singh\*

*Abstract. Acoustic impedance measurements pose a fundamental measurement problem because, of the two primary variables -- acoustic pressure and particle/volume velocity -- only pressure can be measured reliably and accurately in the plane wave regime. Conversely, particle/volume velocity cannot generally be measured at any arbitrary point. Investigators have thus been forced to devise indirect means for measuring acoustic impedances and other characteristics. The most commonly used method is the standing wave tube method [ASTM C384-58, 1972]. But its limitations have forced investigators to search for alternate experimental methods; some of these use digital instrumentation. This paper is a critical review and comparative assessment of these measurement methods.*

Acoustic systems and materials can be characterized by acoustic impedance  $Z(f)$ , which is defined as  $Z(f) = p(f)/Q(f)$ ;  $p$  is the acoustic pressure,  $Q$  is the acoustic volume velocity, and  $f$  is the frequency. A tilde over a symbol indicates that it is a complex quantity and has both magnitude and phase. Other inherent acoustic characteristics such as absorption and reflection coefficients, transmission loss, and four-pole coefficients are related to acoustic impedance [15, 24, 27, 32]. One advantage of using the impedance approach is that excitation sources and loads/terminations can also be described with impedances.

Acoustical theory is somewhat similar to the subjects of electrical transmission lines and structural vibrations. But, unlike these disciplines, acoustics poses a unique and fundamental measurement problem: out of the two primary variables  $p$  and  $Q$ , only  $p$  can be measured reliably and accurately in the plane wave regime. Conversely,  $Q$  generally cannot be measured at any arbitrary point. This problem has forced many investigators over the years to devise indirect

means for measuring acoustic impedances and other characteristics.

### PREVIOUS LITERATURE REVIEWS

In 1949 Beranek [15] provided an authoritative review of the state of the art of measurement attempts; he recommended the standing wave impedance tube method. Gatley and Cohen [30] in 1969 reviewed the literature critically; they investigated several methods for evaluating small acoustic filters and recommended the standing wave tube method. Singh [66] in 1978 published a brief review of the acoustic impedance measurement literature. No other review or assessment of all available measurement methods has been found in the literature. Of course, techniques applicable to some special applications have been reviewed periodically; e.g., by Dean in 1974 for in-situ wall impedance measurement in flow ducts [46].

### STANDING WAVE TUBE METHOD

Perhaps the most commonly used technique is the standing wave impedance tube method [15, 20, 21]. This method was first proposed by Taylor [1] in 1913 and has since been refined. In this method a traversing microphone is used to determine the magnitude and location of successive maxima and minima of standing wave patterns in a tube terminated by an unknown acoustic system. The input impedance, reflection, and absorption coefficients can be calculated from the data obtained. The standing wave method can be extended to transmission loss measurement with an anechoic termination after the muffler/resonator [32, 43].

The standing wave is simple to use but has many shortcomings. Some of these are listed in the table.

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## COMPARISON OF METHODS

Over the years many researchers have found the standing wave tube method unsuitable for their applications and have developed other measurement techniques. The table lists and compares these methods. Space limitations prevent a detailed discussion of these methods. However, the following considerations have been taken into account.

- conceptual considerations
- type of measured acoustic characteristics
- physical setup and inclusion of flow and heat
- frequency limitations
- excitation type and sources
- transducers
- signal processing techniques
- ease of measurement, sources of error, reliability, and validation procedures
- applications

Table. Comparison of Acoustic Impedance Measurement Methods

METHOD		REFERENCE	STRENGTH	WEAKNESS
1	Standing wave tube method (Standard)	15, 20, 21, 30 32, 37, 48, 80	Absolute measurement not required Only one variable (pressure) measured	Limited at lower frequencies Single frequency measurement Time consuming Some measurement reliability problems
2	Modified standing wave tubes	51, 53, 58, 59	Improvements over the standard tube	Adapted toward particular applications
3	"Tone-burst" pulse method	30, 42	Quasi-steady state method	Long tubes required for the separation of waves Single frequency measurement
4	Single pulse method	33	Short measurement time Continuous frequency measurement	Poor dynamic range Tedious instrumentation and data processing
5	Impulse method	66, 67, 76, 78	Short measurement time Continuous frequency measurement Automation possible	Moderate dynamic range Complicated and sophisticated instrumentation and data processing
6	Hot-wire anemometer	26, 61	Direct measurement of both pressure and volume velocity	Hot-wire anemometer calibration problems Unsuitable for general measurement of volume velocity
7	Constar,* volume velocity method	15, 29, 44, 77	Single measurement (pressure)	Only magnitude is measured Constant excitation difficult to maintain
8	Electroacoustic bridge method	15	Acoustical measurements conducted through analogous electrical measurements	Difficult to construct exact analogs
9	Surface method	10, 14, 15	Volume velocity known	Horn driver dynamics can affect results

Table. (continued)

	METHOD	REFERENCE	STRENGTH	WEAKNESS
10	Shaker-piston method	65, 68, 82	Input volume velocity determined by measuring piston motion Excellent dynamic range obtained	Difficult to adapt to a large acoustic system as only low sound levels can be produced
11	Convertible driver method	68	Only two pressure measurements required Excellent dynamic range obtained	Requires proper calibration procedures Driver loading effects can affect measurements
12	Three pressure method	30, 58, 59	Absolute measurements not required	Phase measurements very critical Curve fitting a problem
13	Two-microphone (front & back locations) method	39, 43, 48	Absolute measurements not required	Phase measurements very critical
14	Two-microphone (adjacent-cross correlation) method	52, 70	Standing waves decomposed into incident and reflected waves using cross-correlation technique	Single frequency measurement Mostly used for magnitude determination
15	Two-microphone (adjacent-cross spectral density) method	60, 69, 74, 75, 79, 80	Determination of cross spectral density of two adjacent pressures yields acoustic intensity Reliable and efficient	Elaborate post-data processing Digital two-channel FFT analyzer required Microphone spacing critical at high frequencies Moderate dynamic range
16	Four-pole coefficients measurement method	22, 71-73	Transfer function/building block type measurement; easily combined with theory	Several setups and measurements required Phase measurement critical Exact terminations required
17	Two sources-two microphones method	50	Pressure measurements at only two locations required	Phase measurements very critical Single frequency measurement

#### DIGITAL INSTRUMENTATION METHODS

The advent of such digital instrumentation as the two-channel FFT analyzer and minicomputer-based data acquisition and data processing systems has made several methods possible [53, 60, 65, 66, 69, 74-76, 78, 79]. Some of the promising techniques are as follows

- Two-microphone cross-spectral density method [60, 69, 74, 75, 79]

- Shaker-piston method [65, 68, 82]
- Impulse method [66, 67, 76, 78]

The above mentioned methods have the following advantages over such conventional methods as the standing wave impedance tube method.

1. They should measure both magnitude and phase of complex acoustic characteristics.
2. They should provide a continuous frequency measurement over a wide frequency range.

3. Digital methods should be capable of providing a large dynamic range.
4. These methods should allow the measurements to be conducted in the presence of mean fluid flow and heat sources.
5. These methods should be capable of determining source impedances, especially of fluid machines.
6. Automation using a microprocessor/minicomputer should be possible.

### CONCLUDING REMARKS

The latest acoustic impedance measurement methods based on digital instrumentation are accurate, efficient, repeatable, and reliable. These methods are thus recommended and should be considered as standard alternatives to the standing wave tube method [20].

Experimental modal analysis techniques in acoustics have not yet been developed even though they are now widely used in structural dynamics. A technique based on a digital method for measuring acoustic impedance that will extract and display acoustic mode shapes is currently being developed [82]. Another area of active research is the acoustic intensity technique, especially intensity measurements in the presence of fluid flow and interfering sound sources [74, 75]. The above mentioned topics will be the focus of further investigations.

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## LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about approximate methods for determining the vibrational modes of membranes; and band saw and circular saw vibration and stability.

Dr. J. Mazumdar of The University of Adelaide, Australia, has written a review of the literature dealing with various approximate methods for the study of membrane vibrations that has appeared during the past few years. Recent research dealing with nonlinear effects, forced vibrations, material anisotropy, and other complicating factors is summarized.

Dr. C.D. Mote, Jr., Dr. G.S. Schajer, and Mr. W.Z. Wu of the Department of Mechanical Engineering, University of California, Berkeley, California have written an article reviewing the modest growth of the literature in band saw vibration and circular saw vibration since 1978, plus some articles not previously reviewed.

## A REVIEW OF APPROXIMATE METHODS FOR DETERMINING THE VIBRATIONAL MODES OF MEMBRANES

J. Mazumdar\*

**Abstract.** *This paper is a review of the literature dealing with various approximate methods for the study of membrane vibrations that has appeared during the past few years. Two earlier reviews in this series, published in 1975 and 1979, were surveys of world literature on this subject published from the beginning of the 19th century through part of 1977. The present review continues the survey from that period to the present. Recent research dealing with nonlinear effects, forced vibrations, material anisotropy, and other complicating factors is summarized.*

According to classical theory the vibration of a membrane is governed by the nonhomogeneous wave equation. In the case of free vibration this equation reduces to the homogeneous Helmholtz equation of the form

$$(\nabla^2 + K^2)W = 0, K = \omega/c \quad (1)$$

This is a classical eigenvalue problem with infinitely many solutions corresponding to an infinity of eigenvalues  $K^2$ . It is known that analytical solutions of this eigenvalue problem can be obtained only for certain simple boundary shapes. If, however, the boundary of the membrane is not natural to one of the common coordinate systems for which the Helmholtz equation can be solved using the method of separation of variables, then approximate analytical methods or numerical methods must be used.

Three methods are usually used to obtain approximate solutions of Helmholtz boundary value problems. One method requires that the solution satisfy the differential equation exactly and the boundary conditions approximately. Another method demands a solution that satisfies the boundary conditions exactly and the governing differential equations approximately. The third method seeks a solution

that satisfies both the differential equation and boundary conditions approximately.

This review, like earlier ones [27], describes linear analysis and nonlinear analysis. The effects of such complicating factors as disturbed forcing functions, large-amplitude oscillations, and material anisotropy, all of which complicate the governing equation, are included. The various formulations and solutions of free and forced vibrations are summarized.

### LINEAR ANALYSIS

The two classes of linear analyses, namely free vibrations and forced vibrations, are discussed separately although they can coexist.

**Free vibration analysis.** In the case of free vibration of membranes the governing equation is the time-reduced Helmholtz equation. Bettess [5] recently discussed this eigenvalue problem for regular polygonal domains. He used a conformal mapping technique to transform the domain of the polygon into a circle. He solved the resulting partial differential equation with a computer. Good approximations of the lowest eigenvalues for regular polygons -- particularly the triangle, square, pentagon, and hexagon -- were obtained. A similar approach has long been proposed by Laura and Faulstich [19], who also obtained good approximations using Galerkin's method.

Laura and co-workers used the same procedure to study this eigenvalue problem in polygonal domains with concentric circular perforations [20]. The proposed method involves constructing appropriate coordinate functions that identically satisfy the boundary conditions and uses a variational approach to generate a simple frequency equation.

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Laura and co-workers subsequently investigated the relative precision of approximate methods when determining eigenvalues in domains of complicated boundary shape [21, 24, 44]. Three different approaches – the Ritz method, the finite element method, and the Fourier expansion-collocation method -- were used to obtain the fundamental frequency of a rectangular membrane with an inner circular boundary [24]. Results for the eigenvalues calculated by the three methods were compared. For the worst situation the difference between the results for the eigenvalues using the Ritz method with two-term approximations and the other two methods is of the order of 10%. The best agreements, on the other hand, have differences of the order of 3%. The hexagonal shaped membrane was discussed [21].

A complete list of eigenvalues of the Laplacian on the triangular domain has recently been formulated [40]. For a given eigenvalue of the equilateral triangle, the eigenfunctions are either all symmetric or all complex. The same problem was also discussed earlier in a doctoral dissertation [9].

It is known that the differential equation describing the free transverse motion of a membrane is also the governing equation for other technically important problems. These include axial shear vibration of a long elastic bar, wave propagation in uniform hollow waveguides filled with a homogeneous isotropic dielectric, Seich motion of an enclosed body of water, transient heat conduction problems, and non-steady motion of incompressible fluids in a duct. Some of these problems have been extensively studied; many analogous membrane problems have thus been solved when these problems were solved. For example, Mazumdar [28] recently proposed a method for the study of TE and TM modes in waveguides of very general cross section. He obtained solutions to a number of waveguide problems of various geometrical shapes. These solutions can be used to obtain solutions to analogous membrane problems. Laura and co-workers [22] similarly obtained eigensolutions of a limaçon-shaped membrane. They used their solution for TM modes in electromagnetic waveguides of limaçon-shaped cross section.

A relatively simple formula

$$\omega^2 = \frac{3T}{\rho u_{\max}} \quad (2)$$

for obtaining an approximate fundamental vibrational frequency of membranes of any shape has recently been derived by Hearn [13, 14]. This formula yields comparable results with another simple formula

$$\omega^2 = \frac{T(2.4048)^2}{2\rho u_{\max}} \quad (3)$$

earlier proposed by Jones [17]. Here  $T$  is the tension per unit length,  $\rho$  is the area density, and  $u$  is the iso-amplitude contour function given by  $\nabla^2 u = -2$  and  $u = 0$  on the boundary of the membrane. Hearn [13] obtained fundamental frequency parameters for limaçon-shaped membranes. Subsequent to Hearn's work, Laura [23] compared his earlier results [22] with those of Hearn for limaçon-shaped membranes. Laura showed that remarkably good agreement exists between the two results, confirming the significance of Hearn's simple formula.

Simple approximate formulas for estimating the vibrational frequencies of plates, shells, and membranes have been presented by Jones [18] in an interesting report. These formulas are expressed in the general form  $F = A/W_{\max}$ ;  $F$  is a frequency parameter,  $A$  is a numerical parameter having a constant value for a number of problems, and  $W_{\max}$  is the maximum deflection of an associated static deflection problem. Despite the lack of a formal derivation of this simple formula, it yields good results for a number of problems considered.

In another interesting report Takeyama [47], using the method of a functional constructed from solutions of integral equations, obtained the characteristic frequencies of membranes. In a recently published monograph [6], the vibration of a wide variety of elastic solids, including membranes, is presented. Accurate and approximate formulas are tabulated as they become available. Several numerical examples explaining the use of formulas are included.

Another recent monograph [4] discusses the classical isoparametric inequality concerned with the principal frequency of membranes. The problem of a vibrating membrane when the boundary is either fixed, free, or elastically supported is discussed in detail. Various eigenvalue problems associated with membrane vibration are included. The inequality of Polya and Schiffer has been extended to the problem of non-homogeneous membranes [3]. Variational characteri-

zation of the eigenvalues and conformal mapping are used to establish the theorem for elastically supported homogeneous membranes. Another study used the variational principle [39]; some extension of the results of Payne and Stakgold is given.

A problem much studied in recent years is the isospectral problem; i.e., can two different domains have the same set of frequencies. This problem has also evoked the question: can you hear the shape of a membrane? The problem has been studied in the context of the physical interpretation of the eigenvalue solution of the Helmholtz equation in an interesting paper [38].

**Forced vibration.** When a membrane is driven by an externally applied force distributed over its surface, forced vibration results. Sato [45] studied the forced vibration problem of a composite rectangular membrane consisting of any number of strips of different materials. The theory was developed by the use of Laplace transformation method. The case of a homogeneous rectangular membrane under two types of driving forces was discussed. Sato later [46] studied the forced vibration of a membrane having arbitrary loading and initial and time-dependent boundary conditions. Hamilton's principle was used to discuss the motion; the normal mode solution was found in terms of the eigenfunctions of the corresponding homogeneous membrane. The case of a composite rectangular membrane consisting of any number of strips of different material was also discussed.

The forced vibration of membranes has also been studied by Nagaya [32-34]. He discussed the vibration and dynamic response problems, subjected to time-varying loads [32]. The results for elliptical and crescent-shaped membranes using the Laplace transform method were presented. The problem of a membrane on point supports was studied [33]. The frequency equation was derived by using the exact solution of the dynamic equation, which includes terms representing the reaction forces of the point supports. Numerical results were given for an elliptical membrane with two point supports. Nagaya [34] proposed a method for solving vibration and dynamic response problems of a membrane with a curved boundary and subjected to a general transient load. The response of a parabolic membrane subjected to a uniformly distributed exponentially decaying load was investigated.

The dynamic response of a rectangular membrane to external time-dependent loading has been investigated [36, 37] using singular perturbation. The near-resonance behavior of the membrane was analyzed to determine the effects of viscous damping, bending rigidity, prestress anisotropy, and aspect ratio.

The usual method for studying forced vibrations of continuous systems - including membranes, plates, and shells - is to express the forcing function in terms of the eigenfunctions of the associated free vibration and then use the normal mode expansion procedure. It was shown [26] that this approach can also be used if the membrane is excited by a random pressure field and is subjected to a damping force. The effect of damping on the forced vibration of membranes was also studied with the help of generalized Fourier series [16]. Hearn and Mazumdar [15] recently used the normal mode expansion procedure to study the dynamic response of atrioventricular valves; they used an idealized elastic membrane model. The resulting membrane motion was discussed in relation to the first heart sound.

Another interesting study on forced vibration of a membrane is that of Borisov [7]. He considered a rectangular membrane with fixed boundaries, one of which moves with time. He showed that a decrease in membrane size is accompanied by a steady rise in vibrational frequency and that an increase in membrane size is accompanied by a decrease in frequency.

## NONLINEAR ANALYSIS

The nonlinear vibrations of a membrane have been the subject of some study during the last few years. A number of interesting papers have appeared in the literature recently.

The basic differential equations for the study of nonlinear vibrations of membranes can be obtained from Von Karman's flat plate equations. Many nonlinear axisymmetric problems have been studied in the past using this approach. Approximate analytical methods of nonlinear structural mechanics and methods of numerical integration are commonly used to study such problems.

Nonlinear membrane problems involving large finite strains have recently been studied by Wu [50, 51].

Explicit asymptotic solutions are possible for a rather large class of problems. Two types of asymptotic solutions exist, depending roughly on whether the strain energy density function is dominated by the first or second strain invariants. The theory is applicable to membranes made of any nonlinear material although only Mooney material was considered. Study of nonlinear axisymmetric motion of a circular membrane under a pulse loading [2] has shown that the radical displacement of the membrane should be considered. The effects of the propagation of elastic waves can be disregarded.

Another interesting study on the axisymmetric deformation of annular membranes under the action of surface loads and edge loads has been reported by Weinitschke [49]. The analysis was carried out within both the Föppl theory and the Reissner theory. A comparison of results showing the range of applicability of the two theories was given.

The nonlinear dynamic response of membranes has been studied [12] using the finite element method with explicit time integration. Only axisymmetric problems were discussed. A method was proposed recently for approximate solutions to problems of highly extensible, rubberlike membranes [43]. The Rayleigh principle of minimization of elastic strain energy was used to describe the large amplitude deformation of membranes.

The dynamic behavior of a membrane made of Mooney material and subjected to step pressure loading has also been studied [1]. The conditions for dynamic snap-out instability were discussed, and the relationship between static behavior and dynamic instability was pointed out.

Derivations of the dynamic equations of membranes directly from the general equations of mechanics of nonstandard continua has been presented [10]. Membranes are defined as three-dimensional bodies with a special form of constraints imposed on the kinetic fields.

A study of acceleration waves in nonhomogeneous nonlinear elastic membranes has been reported [41]. The wave was modeled as a curve moving on a fixed surface and carried with it a finite discontinuity in the acceleration field. The method employed in the analysis is the analogue of the singular surface theory used in continuum mechanics.

An interesting study on the nonlinear motion of elastic membranes regarded as thin shells is that of Naghdi and Tang [35]. Solutions that are valid for both compressible and incompressible materials were obtained with a strain energy function that depends on the metric tensor of the membrane.

## PRACTICAL APPLICATIONS

Membranes are extensively used in machine design for compressors, pumps, and pressure regulators. Many missiles have thin membranous lateral bulkheads that are subjected to forced motions in flight. Many musical instruments contain membrane-like components that allow energy to be transformed.

The theory of membrane vibrations has recently been applied in the field of biomechanics to study certain human component models. The theory of membrane vibrations was recently used to characterize and identify structural and pathological states of the mitral valve leaflet and left ventricular myocardium of the human heart [29]. The information was used to correct the associated functional disturbances by palliative surgery or by valve replacement and coronary bypass respectively. Hearn and Mazumdar [15] used a membrane model to analyze the dynamic response of the atrioventricular valves. They first obtained general solutions for the forced and damped vibrations of an idealized elastic membrane. They then adapted the solutions to valve vibration in response to systolic atrio-ventricular pressure loading. The resulting valve motion is discussed in relation to the first heart sound. Heart valve vibrations in terms of the modal vibrations of a circular membrane have also been reported [25, 30].

The theory of vibration of a rubber membrane has practical application in the field of structural mechanics. A rubber membrane was stretched in its plane and then inflated over a circular frame so that the inflated membrane was a paraboloid of revolution [48]. This nonlinear membrane study described the influence of pressure and thickness parameters on the formation of a prescribed membrane shape.

A nonlinear analysis of membrane vibration has been reported for design purposes [42]. Other work on the forced vibration of a membrane that has practical application in design considers the hydraulic impact forcing function [31].

Gottlieb [11] discussed the conditions under which the modes of vibration of an annular membrane can be harmonics. A practical application of this study to the analysis of harmonic properties of certain musical instruments, particularly Indian and Japanese drums, has been indicated.

## EXPERIMENTAL METHODS

During the last five years, experimental work on membrane vibration known to the author has been very limited. An experimental study [8] of the vibration behavior of a tensioned sheet with a rectangular opening was presented. Local buckling phenomena have also been discussed. In order to develop a relation between the displacement response of a rectangular membrane and the wavenumber-frequency spectrum of the pressure field that excites it, experimental results were presented when the membrane was excited by a random pressure field and subjected to a damping force [26]. The results compared favorably with previously published theoretical data.

There thus exists a need for extensive experimental work to validate the many theoretical results if they are to be used for practical problems.

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## BAND SAW AND CIRCULAR SAW VIBRATION AND STABILITY

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*Abstract. Reviews of band saw vibration and circular saw vibration literature were undertaken in 1978. The modest growth of the literature in these fields since then and some articles not reviewed previously are discussed in this review.*

### BAND SAWS

The vibration and stability of wide band saw blades have been investigated using axially moving plate vibration models; membrane stress effects were included. Both classical Ritz and finite element-Ritz methods were used [3, 4]. The dependence of natural frequency on band velocity, normal and tangential edge forces, wheel support systems, wheel tilting, thermal gradients in the band, and prestress of the band was numerically investigated. Few experimental data are available to support the theoretical prediction of significant spectrum dependence upon these variables.

Krylov functions were used [5] to derive the natural vibration frequencies of a band saw blade in flexure and in torsion. The fact that the band is not translating axially in this study substantially limits direct applicability of the results to low speed band saws.

The dynamic stability of a thin strip traveling axially at a constant speed between roller supports was investigated for zero mean random in-plane loading by Kozin and Milstead [6]. Criteria that guarantee stability of a moving strip subjected to random in-plane forces were established. The conditions that guarantee stability for every mode depend upon the stiffness of the band and are independent of band velocity.

The influence of feeding and cutting forces on band static buckling stability has received attention [7]. The wandering of a hack saw blade in the cut was

investigated by Thompson and Taylor [8]. They concluded that the lateral movement of the cutting edge is primarily associated with geometric and metallurgical differences between the set of the teeth. The analysis was developed from kinematic and geometrical arguments. The paper investigated inclusion of the cutting force in the interpretation of blade lateral displacement and cutting behavior.

Dynamic response of a print belt system in which a steel belt is tightly wrapped around driven and idler pulleys has been investigated [9]. Misregistration of character printing is a principal issue; constant belt velocity during impact friction and belt slipping on the pulleys are the fundamental problems rather than belt transverse vibration.

Kirbach and Bonac [10, 11] showed experimentally that increasing membrane stress in the band through tensioning increases torsional natural frequencies and slightly reduces the flexural frequencies. The results were confirmed [3, 4]. The contribution of tensioning is likely to significantly increase the stability of edge loaded bands in technological areas other than band saws.

A review of chain and belt drive papers, some addressing vibration, has been prepared by Fawcett [12].

The most important open problem in band saw vibration research is to develop a verified stability theory that relates band design and operational state to expected vibration. Until system and process designs are coupled to band performance, optimal band design as an organized and integrated process unified through analysis will remain at an impasse.

### CIRCULAR SAWS

Imperfect axial symmetry of a circular saw splits natural mode frequencies into two slightly different

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frequencies. This splitting can inhibit the formation of traveling waves in the rotating circular saw and cause self-excitation [13]. The manner in which radial rim slots and transverse holes in circular plates influence asymmetry and frequency splitting has been discussed [16]. Rotational speeds for resonance in circular saws have been examined theoretically and experimentally [14, 15]. Relationships between traveling wave and tooth contact frequencies are presented.

Application of electromagnetic control of transverse vibration in circular saws has been investigated [17-20]. The saw blade plate separated pairs of electromagnets that opposed each other. Sensor-measured transverse velocity and position of the saw blade were the feedback variables to the control algorithms and orchestrated the magnet activity. A single sensor and magnet pair system have been analyzed and tested in the laboratory and in production [17, 18]. Effective stiffening and damping of the blade plates were demonstrated, although feedback instabilities of the spillover type [21, 22] were difficult to avoid with the very small damping in saw blade plates.

Phase lag between sensor measurement and control action will energize some vibration modes. Increasing the frequency response of the control system increases the frequency and mode number of the energized mode; but, with very low damping, instability will occur nonetheless. Instabilities of 8-10 kHz were excited in a control system designed to suppress saw blade vibrations in the 0-50 Hz band [17, 18]. Dominant amplitude vibration modes in the saw blade have been continuously identified using real-time FFT [19, 20]. The modes were located in space, and electromagnetic excitation was imposed to suppress the specific dominant modes. Two sensors and two or four pairs of magnets were utilized in the mode suppression. The spillover problem was partially side stepped because attention was focused on the modes to be controlled.

The influence of membrane stresses on natural frequencies and buckling of uniform circular plates was computed using the Ritz method [23, 24, 28]. Tables of critical load and frequency factors are presented for nine boundary condition combinations. Frequency factors for tapered, centrally-clamped circular plates including rotation and an axisymmetric

temperature profile have been given [25]. Vibrations and buckling of a tapered thickness circular plate under hydrostatic in-plane forces have been investigated [26]. Stress and vibration analyses of thin, rotating discs were undertaken; annular finite elements were used to describe bending and stretching [27]. The problem of finding the initial stress field that maximizes the fundamental circular plate frequency for a given strain energy has been discussed [29]. This is the fundamental tensioning problem in circular saws about which considerable work has been profited.

Displacements of concentrated, normal, and tangential edge forces to the bending, buckling, and vibration of a centrally clamped circular plate have been analyzed by Srinivasan and Ramamurti [30, 31]. The in-plane stresses were determined in series for a semi-analytical finite element analysis, introduced by Pardo [32, 33], was used to determine the critical load or characteristic frequency. The papers are original and highly recommended.

Roll tensioning involves inducing membrane stresses in circular and band saws by rolling the plates between pinch rolls, thereby inducing residual stresses through plastic deformation. These stresses improve blade vibration and stability. Three regional models have been analyzed [34, 35] and used to predict the residual stresses induced by rolling. One region, defined by the roller path, contained small elastic and plastic strains and was bounded by two elastic, annular regions. One analysis [34] assumed equality of the radial stress across the roller paths; no circumferential plastic strain in the roller path was assumed in the second study [35]. Both assumptions were overly restrictive according to experimental measurement of residual stresses [34]. Circumferential plastic strain in the roller path and variation of radial stress across the roller path have been accounted for [36, 37]. Measurements of roller path indentation were undertaken, as were prediction and measurement of membrane stresses and plate natural frequencies. Examples of optimal rolling conditions were also given. An aluminum plate has been rolled with a sharp edge roller to give a residual stress state that increases the plate fundamental frequency by 30 percent -- a typical frequency increase from such initial stressing processes [38].

Aoyama and Ohmori [39, 40] investigated roll tensioning. The sensitivity of rolling position on the

initial stresses developed, as indicated by changes in plate form (light gap technique), was discussed [39]. The optimal normalized radius for rolling a circular plate was reported as 0.63, although this figure is necessarily model dependent. Tension dependence on roller pressure was discussed [40].

The effectiveness of tensioning procedures has been evaluated by the rim temperature increase required to cause transverse blade instabilities [41, 42]. The optimal normalized radius was reported to be 0.63. The accuracy of cutting with peripheral heating for various rolling tensioning conditions has been examined by Münz [43]. Multiple rolling operations on a blade, rather than a single annular rolling track, resulted in smaller deviations of the blade surface from a true plane when it was peripherally heated.

The use of feedback control of saw blade temperature to reduce blade vibration and cutting accuracy has been evaluated in full scale production [44]. Optimal operation predicted by theory optimized the process operation in these tests. Analyses of the influence of thermal and rotational stresses on natural frequencies of discs have been examined analytically and experimentally [45, 46]. (The reference lists in these papers are not as extensive as they might be.)

Huber [47] discussed the relative merits of inducing residual stresses for blade stability control through induction heating of the plate rather than rolling the plate. Measurements of the plate stiffness and the residual stress distributions were determined using X-ray techniques. The blades were heated and stressed during manufacture. Hsu and Trasi [48] theoretically investigated the residual stresses in a thin plate resulting from an axially symmetric thermal shock over an annulus. The plates yielded according to the von Mises criterion with a temperature dependent yield strength. Sample residual stress distributions resulting from thermal shock were presented. The stress distributions did not correspond to those expected to be desirable for improving transverse stability of blades. The induced residual tangential stress was compressive away from the heating zone.

Fluid bearings, known as saw guides, are being increasingly applied in the position and vibration control of saw blades. Guides are normally supplied by water or water-oil mixtures at line pressures. At

this time only one paper has appeared [49]; however, considerable expansion of this research area is needed.

## CIRCULAR SAW NOISE

Research on saw noise has provided the following important observations:

- (i) The high frequency distinct tones generated by screaming saws are associated with saw blade resonances [50-56]
- (ii) In a nonresonating saw, increases in rotation speed increase the sound pressure level and the frequency content of the generated aerodynamic noise [54-61]
- (iii) In a resonating saw, increases in rotation speed usually increase the frequency of the generated vibration noise [51-56]
- (iv) Geometrical parameters of saw blades strongly affect both aerodynamic and vibration noise generation [51-61]
- (v) Reduction of blade vibration can be achieved by increasing blade or collar damping [61-63]

Despite these observations opinions differ regarding many fundamental saw noise issues. For example, resonance has been associated with both mechanical excitation [63] and aerodynamic sources [51-56]. Moreover, the sources of aerodynamic noise and vibration noise are often assumed to be fundamentally different because the character of the noise generated differs. During resonant vibration noise consists of high intensity discrete tones; during aerodynamic excitation it consists of a broadband frequency distribution. Spectral analyses of hot wire data devoted to identifying vortices shed from the edges of saw teeth in wind tunnel tests [64] and on actual saw teeth [54] were not able to identify dominant periodicity in the flow surrounding tooth cascades. The phase spectrum of the flow in the tooth wake over both tooth surfaces was recently used to observe the shedding of weak vortices [65].

Suggestions for noise suppression through tooth and blade design have often been contradictory. One suggestion is that beveling the tooth faces would reduce resonant vibration noise [57, 67]. However, Pahlitzsch and Rowinski [62] concluded that bevel angle played no role in resonance noise.

They proposed that long, narrow, radial edge slots at the blade rim would eliminate the resonance noise, a conclusion supported by others [53]. Stakhiev [68] found that radial rim slots worsened the blade vibration and recommended annular slots. Dugdale [51] concluded that the effect of slots on vibration was uncertain unless the suppression of a specific vibration mode was sought. He also reported that carbide-tipped saws generate vibration noise more readily than non-tipped blades; the converse was reported by Wakefield and Wray [63].

Recent experiments have conclusively shown that vibration noise is aerodynamically excited [65] and that the sources of aerodynamic and vibration noise are identical [55, 66]. Resonance is excited if the dominant frequency of the fluctuating pressure occurs near a blade natural frequency and if the fluctuating amplitude is sufficiently high and the blade damping is sufficiently small [66]. The saw noise source is predominantly dipole; the frequency corresponds to a Strouhal number of approximately 0.10 for laminar flow and 0.16 for turbulent flow.

Recommendations regarding design of saw teeth for reduced noise generation are available [61, 66]. Tooth tip speed is the most critical design parameter for noise control with a 14-18 dB SPL increase per doubling of tip speed.

#### CLOSING REMARKS

Vibration reduction and control in circular and band saws is accomplished through saw design, manufacturing process specification, and, more recently, on-line vibration control during the cutting process. Notable improvements in vibration control have been implemented over the last decade. Feedback vibration control methods are now being considered in cutting systems; significant growth in this technological area will occur in the next few years. The increasing value of virtually all materials being processed and the decreasing cost of the electronics and instrumentation needed to implement control point to continued expansion of research on active vibration control techniques.

#### ACKNOWLEDGEMENT

The authors express their sincere thanks to the National Science Foundation, the University of

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# BOOK REVIEWS

## COMPUTATIONAL METHODS IN STRUCTURAL DYNAMICS

L. Meirovitch

Sijthoff and Noordhoff Intl. Publishers  
The Netherlands and Rockville, MD, 1980, 439 pp

Professor Meirovitch brings to the reader the latest developments in the analysis of structural dynamics. These developments have been promoted by the advent of electronic computers. Even though the author assumes that the reader is acquainted with undergraduate mathematics and vibration analysis, he allocates the first chapter to the mathematical background of linear algebra necessary for understanding various modelling techniques and computational algorithms.

The book contains 11 chapters and covers discrete, continuous, and discretized systems. Chapters 2 and 6 deal with discrete systems. The formulation of Lagrange differential equations of motion for structural systems and their behavior in the neighborhood of the equilibrium are outlined in Chapter 2. The eigenvalue problem of such classes of systems as conservative, gyroscopic, and nonconservative is defined.

In Chapter 3, the eigenvalue problem is treated; the structure of associated system matrices is examined. The concept of transforming such matrices to the Jordan canonical form by means of a series of similarity transformations is discussed in depth. This chapter also includes the eigenvalue problem for real symmetric, nonsymmetric, and Hermitian matrices. The author shows that the eigenvalue can be interpreted geometrically as the principal axes of the ellipsoid corresponding to the quadratic form associated with the system matrix.

The qualitative and quantitative aspects of the eigensolution are treated in Chapters 4 and 5 respectively. The behavior of the eigensolution for general Hermitian matrices are discussed in terms of the Ray-

leigh and the inclusion principles in Chapter 4. The inclusion principle provides that the estimated natural frequencies tend to decrease with each additional degree of freedom. It is also used to develop Sylvester's criterion for the positive definiteness of a Hermitian matrix. The eigenvalues of the sum of two Hermitian matrices and the Gerschgorin theorems of the eigenvalues distribution are discussed as are the effects of slight changes in the system matrix elements.

Chapter 5 includes a number of computational algorithms. Among these are the Gaussian elimination matrix iteration by the power method, Hotelling's matrix deflation, the Cholesky decomposition, the Jacobi method, the QR algorithm (iteration techniques reduce the system matrix to upper triangular form), and the inverse iteration. The author illustrates the application of these algorithms with numerical examples.

The deterministic response of discrete systems under arbitrary excitations is treated analytically and numerically in the time domain in Chapter 6. The analytical approach includes the impulse response and the convolution integral; the numerical approach follows the discrete-time systems (the excitation is converted into a discrete function of time). The response in the frequency domain and the response under random excitation are not treated in this book. The stability of motion in the neighborhood of equilibrium is briefly discussed.

Chapter 7 deals with the vibration of continuous systems. The Lagrange equation of these systems and the associated eigenvalue are introduced. This chapter contains an extensive treatment of self-adjoint systems and the properties shared by solutions to vibration problems for a large class of distributed parameter systems. An analysis of the boundary-value problems of such vibrating structural elements as rods, shafts, strings, and membranes is given.

The properties of self-adjoint systems can be established without the exact solution of the boundary-

value problem. This fact is of great importance in deriving approximate solutions for systems whose closed-form solution cannot be obtained. In Chapter 8 the problem of approximate solutions by discretization of continuous systems is introduced. The Rayleigh-Ritz method, a number of weighted residual methods including Galeskin's method, and the lumped-parameter method using influence coefficients are discussed.

The essence of the finite element method outlined in Chapter 9 is essentially the classical Rayleigh-Ritz method. The theoretical and computational aspects of the finite element method are directed toward determination of the eigenvalue problem. The author introduces linear and high-order elements. The analysis is extended to include two-dimensional domains in which linear triangular and rectangular elements are utilized.

Chapter 10 gives a number of algorithms pertaining to problems of large number of degrees of freedom. Chapter 11 deals with methods of analysis referred to as substructure synthesis.

The material presented in this book is of a high standard. However, the book does not cover a number of topics of structural dynamics such as the effects of nonlinear structural coupling and responses under random excitations. This book will be very useful to those working in numerical analysis of structural dynamics and is recommended for graduate courses in this area.

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## DYNAMIC ANALYSIS OF OFFSHORE STRUCTURES

C.A. Brebbia and S. Walker  
Butterworths Inc., Woburn, MA, 1979

Offshore structures are subjected to large dynamic forces due to the surrounding environment and must therefore be designed from a dynamics standpoint.

Due to the random nature of waves, stochastic theory plays an important role in the design of these structures. The dynamics imposed upon these structures by wave forces dominate.

This book -- the first of its kind on the subject -- contains a great deal about dynamic aspects. Each of the nine chapters is well written and full of information.

Chapter I introduces the subject. Chapter II develops the fundamentals of *probabilistic processes*, including basic concepts, autocorrelation, and spectral density. Chapter III has to do with the hydrodynamics of sea waves and sea states. Morison's Equation for slender members (stationary) is introduced. The chapter concludes with the Pierson-Moskowitz and JONSWAP spectral formula for sea wave theory.

Chapter IV considers forces on slender bodies; i.e., dynamic wave and earthquake effects. The concluding section of this chapter contains good applications of Morison's Equation.

Chapter V is concerned with diffraction problems of wave theory, wave forces, and earthquake effects. The effects of current and wind characteristics and wind loads and their dynamic effect on slender and large diameter members are considered.

Chapter VII focuses on the vibration of single-degree-of-freedom systems and the spectral density approach. Chapter VIII has to do with multi-degree of freedom systems, including plate and system responses.

The concluding chapter explains the application of spectral analysis in the dynamics of offshore structures. Different types of construction; i.e., one, two, and four legged structures, including platforms, are considered and the proper dynamics applied. The chapter concludes with two interesting sections on lattice-type structure and soil-structure interaction.

The book contains a great deal of information in 323 pages. At times the reviewer felt that there was too much condensation. The book should have contained component mode analysis (substructuring), approximate methods of analysis (Rayleigh-Ritz and Galerkin), and computer programs employing the analytical concepts. The section on modal analysis

is too short and should be expanded. In summary, this is a good book that could be made better with the additions stated.

H. Saunders  
General Electric Company  
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## CABLE STRUCTURES

H. Max Irvine  
M.I.T. Press, Cambridge, MA  
1981, 260 pages, \$40.00

This reviewer has no wish to hide his enthusiasm for this volume of modest size . . . five chapters and 260 pages . . . about cables and cable structures. This gem is full of insights indispensable to the engineer concerned with moorings, guyed structures, and cable-stayed or suspension bridges. Irvine is a modern master of the approximate solution, and his obvious interest in the underlying physical processes is a pleasant contrast to the contemporary tendency in cable literature toward number crunching.

As recounted in the first chapter, entitled "Historical and Classical Matters," the study of cable statics and vibrations has been pursued for quite some time . . . since the late 16th century. The lowest transverse frequency of a taut cable,

$$\omega = \frac{\pi}{L} \sqrt{\frac{T}{\rho}}$$

is of course simplicity itself and, contrary to longitudinal modes, is totally independent of the elastic properties of the cable. In one sense, however, this apparent simplicity is deceptive -- the value of  $\omega$  is unobtainable as the limit of corresponding frequencies for slightly slack cables unless their elasticity is taken into account in the limiting process.

In the years preceding 1974 when Irvine's thesis on cables was published, a number of authors perceived the nature of this difficulty. However, it was Irvine who first explained it clearly and conclusively; and it was he who exhibited the single parameter, depen-

dent both on cable geometry (slackness) and elasticity, which control the behavior of the natural modes of the cable.

His results have led to a full understanding of the phenomenon of frequency cross-over for the in-plane modes of a slack cable. (This reviewer admits to having crunched some numbers on cables containing, in addition to their own mass, some nonuniformly distributed lumped masses only to find that, qualitatively at least, the cross-over phenomena predicted by Irvine's theory remain intact.) With regard to Irvine's theory, its important frequency-controlling parameter is important in calculating both static behavior and the dynamics of cables. The slack cable phenomena, including frequency cross-over, that were predicted by Irvine, have since been verified in numerous reported experiments.

All this and many more goodies are contained in detail in Cable Structures. Chapters 2 and 3 deal respectively with the statics and dynamics of single cables. The author notes that because of the approximations which have been made, results should be applied only to a cable whose sag does not substantially exceed one-eighth its length; most situations of practical interest are thus covered. Sections on large amplitude vibrations and on plastic stress waves are included.

Chapter 4 describes applications of cable theory to cable trusses and bridges. The last chapter is devoted to extending the theory to three dimensions; i.e., membrane structures. Throughout the book theory is elucidated with interesting examples and extended with numerous application-oriented exercises with stated answers.

Cable Structures should be of great value to any practicing engineer who needs to analyze the statics or dynamics of structures containing cable elements: cable stayed and suspension bridges, guyed towers, cable roofs, inflatable structures, marine cable structures, and mooring systems. The lucid style is readable by undergraduate students although the specialization on cable structures recommends it more for graduate courses in Civil Engineering.

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# SHORT COURSES

## MARCH

### **VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION**

Dates: March 1-5, 1982

Place: College Park, Maryland

Dates: April 12-16, 1982

Place: Dayton, Ohio

Dates: July 19-23, 1982

Place: England

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

### **MEASUREMENT SYSTEMS ENGINEERING**

Dates: March 1-5, 1982

Place: Phoenix, Arizona

### **MEASUREMENT SYSTEMS DYNAMICS**

Dates: March 8-12, 1982

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness of data acquisition systems and groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

### **MECHANICAL RELIABILITY, DESIGN BY RELIABILITY, PROBABILISTIC DESIGN -- THE STRESS/STRENGTH INTERFERENCE APPROACH TO RELIABILITY PREDICTION**

Dates: March 15-19, 1982

Place: Los Angeles, California

Objective: To cover the following: how to predict the designed-in reliability of mechanical components subjected to static and fatigue loads; synthesize the failure covering stress and strength distributions for each component and for each significant failure mode; calculate the associated reliabilities at desired confidence levels; use computer and Monte Carlo simulation techniques to synthesize the failure governing stress and strength distributions and calculate the associated reliability for any combination of these two distributions; design specified reliabilities into components at desired confidence levels.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Dept., University of Arizona, Building 16, Tucson, AZ 85721 - (602) 626-2495.

### **EXPLOSION HAZARDS EVALUATION**

Dates: March 15-19, 1982

Place: San Antonio, Texas

Objective: This course covers the full spectrum of problems encountered in assessing the hazards of such accidental explosions, in designing the proper containment as necessary, as well as developing techniques to reduce incidence of accidents during normal plant and transport operations. Topics covered include: fundamentals of combustion and transition to explosion; free-field explosions and their characteristics; loading from blast waves; structural response to blast and non-penetrating impact; fragmentation and missile effects; thermal effects; damage criteria; and design for blast and impact resistance.

Contact: Wilfred E. Baker, Engineering Sciences Division, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111.

### **SHOCK AND VIBRATION CONTROL**

Dates: March 16-18, 1982

Place: Southampton, England

Objective: Topics include structural parameters and their role in vibration control, dynamic properties of

structural materials, damping materials and their properties, application of damping treatments to structures, fibre reinforced plastics, fatigue, mobility methods, vibration transmission through structures, power flow, shock, effects of structural parameters on acoustic radiation, isolation, machinery installations, the transient environment, packaging and packaging materials.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, SO9 5NH - (0703) 559122, Ext. 2310.

### **COMPUTER SIMULATION OF HIGH VELOCITY IMPACT**

Dates: March 23-25, 1982

Place: Baltimore, Maryland

Objective: This course provides an overview of the response of materials and structures to intense impulsive loading. The various numerical methods available for impact problems are reviewed together with the corresponding material models and failure descriptions. Two- and three-dimensional computer programs for wave propagation, impact and penetration are reviewed, their capabilities and limitations highlighted and computational results compared with experiments where possible. Computer graphics packages for mesh generation and data analysis are also covered.

Contact: Dr. J.A. Zukas, Course Coordinator, (301) 278-2076; or Computational Mechanics Associates, P.O. Box 11314, Baltimore, MD 21239.

### **CORRELATION AND SPECTRAL ANALYSIS FOR ENGINEERING AND SCIENTIFIC APPLICATIONS**

Dates: March 23-26, 1982

Place: Boston, Massachusetts

Objective: This course covers important engineering applications of correlation and spectral analysis relative to acoustics, mechanical vibrations, system identification and fluid dynamics problems in the aerospace, automotive, industrial noise control, civil engineering and oceanographic fields. Applications include identification of system properties and response effects, estimation of time delays and propagation velocities, determination of energy sources, and utilization of practical statistical error formulas to evaluate results. Comprehensive methods

are explained to solve single input/single output problems, single input/multiple output problems and multiple input/multiple output problems, where arbitrary correlation and coherence functions (ordinary, partial, multiple) can exist among the records.

Contact: Continuing Education Institute, 10889 Wilshire Blvd., Suite 1030, Los Angeles, CA 90024 - (213) 824-9545; or Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044 - (301) 596-0111.

### **COMPUTER APPLICATIONS IN EARTHQUAKE ENGINEERING**

Dates: March 29-31, 1982

Place: Chicago, Illinois

Objective: The objective of this seminar is to disseminate information about new computer applications developed from recent research in earthquake engineering. The methodology and computer software in current use, as well as future developments, will be described by the lecturers. Among the topics to be discussed are stochastic analysis of structural systems, linear and nonlinear dynamic analysis of structures, 2D and 3D soil-structure interaction, multistory building programs, spectral combination method and analysis for multi-component spectra.

Contact: National Information Service for Earthquake Engineering (NISEE), Computer Applications, 519 Davis Hall, University of California, Berkeley, CA 94720 - (415) 642-5113.

### **GEAR NOISE**

Dates: March 23-25, 1982

Place: Columbus, Ohio

Objective: The course will cover general noise measurements and analysis, causes of gear noise, dynamic modeling, gear noise signal analysis, and modal analysis of gear boxes. Problems of course attendees will be discussed in a special workshop session. Laboratory demonstrations and research efforts of the Ohio State University Gear Dynamics and Gear Noise Research Laboratory will also be presented.

Contact: Richard Frasher, Director of Continuing Education, College of Engineering, The Ohio State University, 2070 Neil Avenue, Columbus, OH 43210 - (614) 422-8143.

## **APRIL**

### **DESIGN OF FIXED OFFSHORE PLATFORMS**

Dates: April 5-16, 1982

Place: Austin, Texas

Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas, Austin, TX 78712 - (512) 471-3506.

### **MACHINERY VIBRATION ANALYSIS**

Dates: April 13-16, 1982

Place: Philadelphia, Pennsylvania

Dates: June 15-18, 1982

Place: Seattle, Washington

Dates: August 17-20, 1982

Place: New Orleans, Louisiana

Dates: November 9-12, 1982

Place: Oak Brook, Illinois

Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow speed paper rolls.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

# NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

## **Announcement and Call For Papers**

### **SIXTH IFTOMM CONGRESS ON THEORY OF MACHINES AND MECHANISMS New Delhi, December 15-20, 1983**

The Sixth World Congress of the International Federation of Theory of Machines and Mechanisms (IFTOMM) will be held in New Delhi, India.

The topics covered will include: Kinematic Analysis and Synthesis; Dynamics of Machines and Mechanisms; Gearing and Transmission; Rotor Dynamics; Vibration and Noise in Machines; Biomechanisms; Technology Transfer; Robots; Manipulators and Man Machine System; Control of Mechanisms; Industrial Applications for Special Machines and Mechanisms; History of TMM; Experimental Methods, Teaching Methods, and related topics.

The technical sessions will be held at Indian Institute of Technology, Hauz Khas, New Delhi. Hotel accommodation will be arranged on request. Limited accommodation will be available in students hostels nearby the Institute and transport will be provided during the Conference. In addition to technical papers, there will be a series of keynote addresses by internationally known speakers in various fields of Machines and Mechanisms. Industrial and Book Exhibitions are planned.

Prospective authors should submit abstracts (original and two copies) of their papers by April 15, 1982 to the Chairmen of their national committees for review and approval. Residents of those countries that do not have formal membership of IFTOMM should send their abstracts to the Chairman of Papers Committee. Names and addresses of the Chairmen of National Committee and the addresses of the Chairmen of Papers Committee can be obtained by contacting Prof. J.S. Rao, listed below.

Authors will be notified by August 15, 1982 of the acceptance of their proposed papers by the Chairman of IFTOMM National Committee or the Chairman of the Papers Committee, along with detailed instruc-

tions concerning the submission of the full papers by December 15, 1982.

Abstracts must not exceed 500 words in length and should be typed double spaced with ample margin on A 4 or 8½ x 11" size paper. Not more than two papers bearing a particular name as author, or co-author can be accepted.

For further information, contact: Professor J.S. Rao, Department of Mechanical Engineering, Indian Institute of Technology, New Delhi 110016 (India), Telephone 654187.

### **SECOND INTERNATIONAL CONFERENCE ON APPLIED MODELING AND SIMULATION Vallée de Chevreuse (Paris-Sud), France July 1-3, 1982**

Modeling concerns the schematic description of systems and devices, whereas simulation is the use of the models to investigate and/or optimize the processes without experimenting on the real systems. The aim of the Conference is to strengthen the contact between developers and users of modeling and simulation techniques.

Topics will include: methodology; simulation methods; electrical and electronic engineering; mechanical engineering; energy and thermal devices; materials; resources; life -- biology, evolution, ecology, physiology, health, and medicine; men -- psychology, education, languages, arts, and sports; organization -- management, trade, economics, finance, politics, and problems of societies; urbanism; transportation; communications; traffic; and habitat.

The Conference is sponsored by IASTED, The International Association of Science and Technology for Development and is being organized by AMSE, Association for the Advancement of Modeling and Simulation Techniques in Enterprises.

For further information, contact: AMSE, 16 avenue de Grange Blanche, 69160 Tassin la Demi Lune, France.

**77th ANNUAL MEETING  
SEISMOLOGICAL SOCIETY OF AMERICA  
April 19-21, 1982  
Anaheim, California**

The 77th annual meeting of the Seismological Society of America will be held in conjunction with the annual meeting of the Cordilleran Section GSA, April 19-21, 1982 in Anaheim, California.

The 1982 meeting will feature a number of special symposia, with invited papers aimed at a critical assessment of issues in several areas of seismological research. The symposia are intended not only to serve as a state-of-the-art overview, but also to help consolidate gains that have been made over the years, provide directions for future research, and explore controversial issues with the goal of reducing the level of controversy. Symposia planned for the Anaheim meeting are the following:

- The Decision-Making Process in Siting Critical Facilities
- Strong Ground Motion Prediction
- Test Ban Treaty Verification Research
- Computational Seismology I: Theoretical Research
- Computational Seismology II: Use of Computers in Network Seismology
- Earthquake Prediction

For further information, contact: Seismological Society of America, 2620 Telegraph Avenue, Berkeley, CA 94704 - (415) 848-0954.

**1982 DESIGN AUTOMATION CONFERENCE  
September 12-15, 1982  
Washington, D.C.**

The Eighth Design Automation Conference will be held in conjunction with the 17th Biennial Mechanisms Conference on September 12-15, 1982 at the Key Bridge Marriott Hotel in Washington, D.C. These conferences are sponsored by the Design Engineering Division of the American Society of Mechanical Engineers.

The ASME Design Automation Committee has invited authors to submit papers in the broad areas of Design and Automation including:

- Man-Machine Interaction
- Computer Graphics and Drafting
- Optimization and Numerical Methods
- Mechanical Design Applications including Social, Economic, and Legal Aspects
- CAD/CAM Systems
- Hardware/Software System Evaluation
- Finite Element Analyses
- Intelligent Machines and Robotics

For further information, contact: Prof. Kenneth M. Ragsdell, Purdue University, School of Mechanical Engineering, West Lafayette, IN 47907 - (317) 494-8607.

# INFORMATION RESOURCES

## CHEMICAL PROPULSION INFORMATION AGENCY (CPIA)

### BACKGROUND AND MISSION

The Chemical Propulsion Information Agency (CPIA) is a Department of Defense Information Analysis Center active in the field of chemical rocket, ramjet, and gun propulsion. It has been in continuous operation at The Johns Hopkins University, Applied Physics Laboratory (APL), since 1946. CPIA collects, reviews, analyzes, appraises, and summarizes technical information on solid, liquid, hybrid, and electric rockets, ramjets, and gun propulsion systems.

In addition to operating as a DoD Information Analysis Center, CPIA provides technical and administrative support to the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee. This JANNAF Committee is a continuing, federally chartered group whose charter is reviewed and reexecuted every two years and whose purpose is to solve propulsion problems, effect coordination of technology programs, and promote an exchange of technical information in the fields of rocket, ramjet, and gun propulsion based on chemical or electrical energy release. The technical areas of interest of the JANNAF Interagency Propulsion Committee, and hence of CPIA, include chemical synthesis; manufacturing process development; analytical test techniques; thermochemistry; combustion phenomena; interior ballistics; physical, chemical, and mechanical properties of propellants and other rocket components; special test equipment and techniques; theoretical and experimental performance; component and propulsion unit design; low cost materials and designs; reliability; safety and environmental protection; exhaust plume technology; and operational life and serviceability.

The Defense Technical Information Center (DTIC) is the Administrative Manager for the CPIA DoD Information Analysis Center. The Naval Air Systems command has the Technical Management responsibility. Funding for CPIA is provided by DTIC, Army,

Navy, Air Force, NASA, other government agencies, private industry, and educational institutions.

### THE STAFF

The professional staff consists of ten engineers, chemists and information specialists and the supporting staff includes 11 administrators, secretaries and technicians. The average period of service at APL is in excess of 13 years. The interests and specialties of the staff are as varied and sophisticated as the problems and needs expressed by the propulsion community.

The complete facilities of the IBM 370/158-IBM 3033 computer system and CRT and teletype terminals are available for use in information retrieval as well as for the solution of propulsion-related problems. Modern information processing and handling equipment is available, including microfilm/fiche readers and printers for use by visitors.

### SOURCES AND DATA BASE

A unique library is maintained which documents the research, development, testing, and evaluation of solid, liquid, airbreathing, and gun propellants and propulsion hardware. It now contains over 52,000 technical reports, papers, and data sheets dating to 1946 and grows at the rate of about 1500 items annually. All the material is indexed in depth by the professional staff members who are familiar with the particular subject area. The technical report literature from 1969 to date (about 15,000 citations) is computer-searchable in-house at CPIA.

Over 500 meeting bulletins, handbooks, manuals, and special publications have been issued by CPIA and its predecessor agencies since 1946.

Sources of information and data are chemical propulsion contract and government laboratory technical progress reports, bulletins of the proceedings of technical meetings coordinated and attended by staff members, questionnaires submitted to CPIA by participants in the information exchange effort, trip reports of visits by staff members, consultations with visitors and those making technical inquiries to CPIA, and information gained through the close technical and administrative support of JANNAF activities.

By virtue of CPIA's JANNAF duties, the staff interacts with about 800 Government and industry representatives currently affiliated with JANNAF (an additional 1000 are on the Subcommittee rosters). These professional contacts with the nation's propulsion technology experts add immeasurably to CPIA's reservoir of information.

Through its parent organization, the Applied Physics Laboratory of The Johns Hopkins University, CPIA also has access to many on-line databases, including the collections of the Defense Technical Information Center (DTIC), National Technical Information Service (NTIS), NASA, and American Institute of Aeronautics and Astronautics (AIAA).

#### **CPIA Activities**

The staff of CPIA prepares publications and manuals, provides JANNAF support, coordinates technical meetings, and offers reference assistance in response to specific requests.

### **PUBLICATIONS**

**The Chemical Propulsion Abstracts** contains abstracts of reports of U.S. Government sponsored research and development programs in chemical propulsion and is indexed by subject, author, corporate source, and contract number.

**Chemical Propulsion Technology Reviews** are summaries and status reports on topics pertaining to rocket, ramjet and/or gun propulsion. The objective is to collect, analyze, condense and discuss technical advancements in a language understandable by a broad range of propulsion technologists.

**The CPIA/M1 Rocket Motor Manual** contains general descriptions of solid propellant rocket motors used

for tactical, strategic, space, JAT and sounding rocket applications.

**The CPIA/M2 Solid Propellant Manual** includes data on the composition and on the physical, chemical, ballistic and safety properties of both service-accepted and experimental solid propellant formulations.

**The CPIA/M3 Solid Propellant Ingredients Manual** contains data on the chemical, physical, thermodynamic and safety properties of ingredients used in solid propellants.

**The CPIA/M4 Liquid Propellant Manual** is a compilation of the properties of liquid propellants and is intended to provide a survey of the physicochemical characteristics and performance of selected propellants and promising propellant candidates.

**The CPIA/M5 Liquid Propellant Engine Manual** contains descriptions of engines which are now in use or have been operated in a lightweight configuration.

**The CPIA/M6 Airbreathing Propulsion Manual** contains descriptions of the propulsion units and fuels used or designed for use in airbreathing missile systems.

**Meeting Bulletins** containing the papers presented at JANNAF annual propulsion meetings, specialist meetings, and subcommittee meetings are compiled and published.

**Subcommittee Publications** are prepared for the purpose of standardizing nomenclature, specifications, test methods and equipment, and to provide information and direction in the area of specialization of the subcommittee.

**The Chemical Propulsion Mailing List** is maintained by CPIA to establish the mechanism for direct exchange of chemical propulsion technical information among selected government facilities and contractors.

**Literature Searches** are prepared, using the Chemical Propulsion Abstracts as the source data base, in response to specific requests or initiated within CPIA to treat topic areas known to be of broad current interest in the propulsion community.

The CPIA Bulletin is a bimonthly newsletter which contains information on the JANNAF activities, CPIA services and products, and items of general interest to the propulsion community. It is unclassified and is widely distributed.

#### **Technical Inquiries**

Technical inquiries are answered by the staff members who specialize in the problem area under investigation. A personal visit to CPIA is encouraged, especially when conducting extensive literature searches. Limits are placed on technical inquiry services and visits in accordance with the amount of service charge paid by an organization. Extensive efforts which exceed a category limit must be negotiated separately.

### **JANNAF SUPPORT**

The JANNAF Committee consists of an Executive Committee, ad hoc committees, and ten subcommittees. Technical meetings and projects are organized by the ad hoc committees and subcommittees with the concurrence of the Executive Committee and with the technical and administrative support of CPIA. The annual meeting is attended by 800 to 1000 scientists and engineers from Government and the US propulsion communities. Subcommittee meeting bulletins, guidelines and procedures, and handbooks and manuals are published by CPIA as they receive JANNAF approval.

### **AVAILABILITY OF CPIA SERVICES**

#### **Registration with DTIC**

In order to receive CPIA services, recipients are required to maintain an active registration with the Defense Technical Information Center (DTIC) at the confidential or higher security level and have the proper "need-to-know." Registration with DTIC results in the facility's being assigned a DTIC User Code Number and being included in the Department of Defense Dissemination Authority List (DAL).

#### **Service Charge**

In accordance with a ruling by the Department of Defense, CPIA instituted a system of service charges in 1969. The service charge is based upon recovery of the total costs of the agency's output function and includes separate charges for abstracts and indexes, technology reviews, propulsion manuals, JANNAF meeting proceedings and special publications, inclusion on the Chemical Propulsion Mailing List, literature searches, and technical/bibliographic inquiry time. A current price schedule is available upon requests.

#### **Mailing Address**

The Johns Hopkins University  
Applied Physics Laboratory  
Chemical Propulsion Information Agency  
Johns Hopkins Road  
Laurel, Maryland 20707

#### **Telephones**

Washington Line (301) 953-7100, ext. 7800  
Baltimore Line (301) 792-7800, ext. 7800

# ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Zeeb St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, DC 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

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# MECHANICAL SYSTEMS

## ROTATING MACHINES

(Also see Nos. 287, 364, 468, 508, 539)

82-255

### Optimal Control of a Rotating Cylinder Partially Filled with Liquid. Progress Report

S.L. Hendricks and C.K. Carrington  
School of Engrg. and Applied Science, Virginia Univ.,  
Charlottesville, VA, 49 pp (Feb 1981)  
UVA-ER-627-81U

**Key Words:** Rotors, Flexible rotors, Fluid filled containers, Stability

When a flexible rotor is partially filled with liquid there is a range of operating speeds over which the system is unstable. This report documents the attempts to control the motion of the rotor while operating in this unstable range by adding an external control force to the system. The governing equations are put in state space form and used in an optimal control (linear regulator) analysis. The governing equations for a two-dimensional inviscid fluid contained in two different rotor models have been developed. They give good results for the eigenvalues (frequencies and  $Q_s$ ). The optimal control analysis has not been completed due to numerical problems in the integration of the Riccati equation.

82-256

### Rotor Dynamic Inflow Derivatives and Time Constants from Various Inflow Models

D.M. Pitt  
Army Troop Support and Aviation Materiel Readiness Command, St. Louis, MO, Rept. No. TSARCOM-TR-81-2, 235 pp (Dec 1980)  
AD-A099 532

**Key Words:** Rotors, Transient response

A linear, unsteady theory is developed that related transient rotor loads (thrust, roll moment, and pitch moment) to the overall transient response of the rotor induced-inflow field. The relationships are derived from an unsteady, actuator-disc theory; and some are obtained in closed form. The theory

is used to determine the effects of lift distribution and shaft angle-of-attack on the said relationships. Also, two different assumptions are used in the unsteady calculations, finally, a prescribed wake analysis is used to validate the actuator-disc theory for normal flight conditions. The results reveal both the strengths and weaknesses of previous formulations and reveal areas in which further study is needed. The most significant result is an analytic, three-degree-of-freedom inflow model that is shown to be accurate for use in the dynamic analysis of rotors.

82-257

### External of Internal Bearings for Turbochargers -- A Comparison with Particular Reference to Rotor Dynamics and Bearing Properties

H. Hörler and H. Ammann  
Brown Boveri Rev., 68, pp 188-196 (May 1981) 6  
figs, 6 refs

**Key Words:** Rotors, Bearings

Two different types of bearings have proved successful on the turbocharger market: bearings at the shaft ends (external bearings), used predominantly in large machines, and bearings between the compressor and turbine wheel (internal bearings) used mainly for small turbochargers. This paper describes the basic differences with the help of calculations and by considering the experience gained, with emphasis on the dynamic behavior of the rotor and the requirements to be met by the bearings. External bearings result in smaller bearing forces and require smaller clearances at the compressor wheel and turbine wheel. The frictional losses in the bearings are smaller, particularly at part load. For the external bearings, either plain bearings or rolling-contact bearings with a self-lubricating system may be used. Access to the bearings is thus better. However, for specific applications internal bearings have advantages, which relate mainly to the wider variety of ways of fitting the turbocharger to the engine.

82-258

### Stick-Slip of Rotors in Fluid Bearings at Very Low Speeds

D. Michalopoulos and A. Dimarogonas  
Mach. Des. Lab., School of Engrg., Univ. of Patras,  
Patras, Greece, Wear, 70 (3), pp 303-309 (Aug 15,  
1981) 5 figs, 10 refs

**Key Words:** Rotors, Fluid-film bearings, Stick-slip response

The stick-slip phenomenon which occurs at very low speeds with rotors in fluid bearings was studied analytically and

experimentally to improve understanding of the phenomenon and to identify the controlling factors. A flexible rotor in fluid bearings was studied at low speeds. The function describing the coefficient of friction versus the linear velocity was found to have a concave form and to be strongly dependent on the bearing load. Polynomial expressions were used to obtain an exponential law. The system stability was investigated by means of numerical integration of the equations of motion. Areas of instability predicted by the analytical model are in close agreement with the experimental results. Damping was found to have a strong influence on the stability of the system.

**82-259**

**Blade Loss Transient Dynamics Analysis, Volume 1:  
Task 1: Survey and Perspective**

V.C. Gallardo, E.F. Gaffney, L.J. Bach, and M.J. Stallone

Aircraft Engine Business Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-165373-V-1, R81AEG381-V-1, 22 pp (June 1981)  
N81-27089

**Key Words:** Rotors, Unbalanced mass response, Blade loss dynamics, Turbine blades, Turbine engines, Computer programs

An analytical technique was developed to predict the behavior of a rotor system subjected to sudden unbalance. The technique is implemented in the Turbine Engine Transient Rotor Analysis (TETRA) computer program using the component element method. The analysis was particularly aimed toward blade-loss phenomena in gas turbine engines. A dual-rotor, casing, and pylon structure can be modeled by the computer program. Blade tip rubs, Coriolis forces and mechanical clearances are included. The analytical system was verified by modeling and simulating actual test conditions for a rig test as well as a full-engine, blade-release demonstration.

**82-260**

**Analytical Study of the Effects of Wind Tunnel  
Turbulence on Turbofan Rotor Noise**

P.R. Gliebe

General Electric Co., Cincinnati, OH, J. Aircraft, 18 (10), pp 818-825 (Oct 1981) 14 figs, 1 table, 15 refs

**Key Words:** Turbofans, Rotors, Wind tunnel tests, Turbulence

An analytical study of the effects of wind tunnel turbulence on turbofan rotor noise was carried out to evaluate the effectiveness of the NASA Ames 40 x 80-ft wind tunnel in simulating flight levels of fan noise. A previously developed theory for predicting rotor/turbulence interaction noise, refined and extended to include first-order effects of inlet turbulence anisotropy, was employed to carry out a parametric study of the effects of fan size, blade number, and operating line for outdoor test stand, NASA Ames wind tunnel, and flight inlet turbulence conditions. Although wind tunnel rotor/turbulence noise levels are not as low as flight levels, they are substantially lower than the outdoor test stand levels and do not mask other sources of fan noise.

**82-261**

**Semi-Actuator Disk Theory for Compressor Choke  
Flutter**

J. Micklow and J. Jeffers

Government Products Div., Pratt and Whitney Aircraft Group, West Palm Beach, FL, Rept. No. NASA-CR-3426, FR-12976, 169 pp (June 1981)  
N81-25075

**Key Words:** Compressors, Compressor blades, Blades, Flutter

A mathematical analysis predicting the unsteady aerodynamic utilizing semi actuator theory environment for a cascade of airfoils harmonically oscillating in choked flow was developed. A normal shock is located in the blade passage, its position depending on the time dependent geometry, and pressure perturbations of the system. In addition to shock dynamics, the model includes the effect of compressibility, interblade phase lag, and an unsteady flow field upstream and downstream of the cascade. Calculated unsteady aerodynamics were compared with isolated airfoil wind tunnel data, and choke flutter onset boundaries were compared with data from testing of an F100 high pressure compressor stage.

**82-262**

**A Vibration Source in Refrigerant Compressors**

K. Imaichi, N. Ishii, and K. Imasu

Osaka Univ., Japan, ASME Paper No. 81-DET-72

**Key Words:** Compressors, Shafts, Crankshafts, Torsional vibration, Flexural vibration, High frequency response

This paper discusses vibration sources in refrigerant compressors. It is shown that the higher frequency damped variations observed were caused by torsional and transversal elastic

vibrations of the crankshaft which had a motor rotor of larger mass at one end of the comparatively long and slender shaft. Moreover, it is confirmed that the crankshaft is one of the major vibration sources which cause higher frequency vibrations of the compressor in constant operation.

#### 82-263

##### **Experimental Research on the Hydraulic Excitation Force on the Pump Shaft**

H. Kanki, Y. Kawata, and T. Kawatani  
Mitsubishi Heavy Industries, Ltd., Takasago City,  
Japan, ASME Paper No. 81-DET-71

**Key Words:** Shafts, Pumps, Hydraulic equipment

The experimental test results to get hydraulic exciting force which acts on the pump impeller are described for the rotordynamics analysis in pump design works. The tests were performed on typical model pumps by applying the highly advanced measuring techniques.

#### 82-264

##### **Vibrations of Rotating Circumferentially Periodic Structures**

J. Wildheim  
STAL-LAVAL Turbin AB, Finspong, Sweden,  
Quart. J. Mechanics Appl. Math. 34 (2), pp 213-229  
(May 1981) 5 figs, 8 refs

**Key Words:** Rotating structures, Periodic structures, Natural frequencies, Mode shapes

The paper considers the free, undamped vibrations of rotating, circumferentially periodic structures. Due to the rotation, Coriolis effects are present as well as centrifugal and geometric stiffness effects. It proves to be the presence of Coriolis effects, represented by skew-symmetry in the equations of motion, that the natural modes of the system consist of backward and forward rotating mode shapes. The backward and forward rotating mode shapes with the same wave number inherently vibrate with different frequencies. Therefore, standing natural mode shapes cannot be found in rotating, circumferentially periodic structures (except in those cases where the deflection is the same at corresponding points on every substructure in which case the mode shape may be interpreted as standing). A method of complex constraints is applied to the substructures which reduces the equations of motion for the complete structure to a set of equations of motion pertaining to a single substructure. The number of equations is reduced in the same proportions and the computational benefits are dramatic.

#### 82-265

##### **Performance and Noise of a Low Pressure Ratio Variable Pitch Fan Designed for General Aviation Applications**

F.B. Metzger, R.W. Menthe, and C.J. McColgan  
Hamilton Standard, Windsor Locks, CT, Rept. No.  
NASA-CR-159246, 105 pp (Jan 31, 1980)  
N81-27099

**Key Words:** Fans, Aircraft equipment, Noise generation

A limited study has been conducted to establish the performance and noise characteristics of a low design tip speed (168 m/s, 550 ft/sec) low pressure ratio (1.04) variable pitch fan which was tested in the Langley 30 x 60 tunnel. This fan was designed for minimum noise when installed in the tail mount location of a twin engine aircraft which normally has both nose and tail mounted propulsors. Measurements showed the fan noise to be very close to predictions made during the design of the fan and extremely low in level (65 dBA at 1000 ft) with no acoustic treatment. This is about 8 dB lower than the unshrouded 2 blade propeller normally used in this installation.

## **POWER TRANSMISSION SYSTEMS**

(See No. 512)

## **METAL WORKING AND FORMING**

#### 82-266

##### **Identification of Noise Sources of Forge Hammers During Production: an Application of Residual Spectrum Techniques to Transients**

M.W. Trethewey and H.A. Evensen  
Dept. of Mech. Engrg. and Engrg. Mech., Michigan  
Tech. Univ., Houghton, MI 49931, J. Sound Vib.,  
77 (3), pp 357-374 (Aug 8, 1981) 9 figs, 3 tables,  
29 refs

**Key Words:** Forging machinery, Noise source identification, Spectrum analysis

Three gravity-drop, four-piece forge hammers are analyzed to determine the principal structural sources of impulsive noise radiation during production forging. A three-input single-output model is used to describe the hammer system, based on "input" signals taken from one column, the anvil and the ram accelerations, and one "output" signal taken from the sound pressure at the operators' position. The frequency

response functions between the elemental vibrations and the sound pressure signal are determined from these signals by residual spectrum techniques. For the three hammers studied, the analysis shows that the ram is a major source of acoustic energy radiated to the operator's position, while the columns and anvil radiate between 1 and 4 dB less energy. The three-input model is then used to estimate the effect of acoustic shrouds on the sound energy radiation. The results indicate that it may be necessary to treat all the structural elements before significant reductions can be achieved, due mainly to the high degree of interaction between the components.

**82-267**

**Mathematical Modelling for Predicting Effects of Structural Changes in Machine Tools**

A.R. Whittaker and M.M. Sadek

The Univ. of Birmingham, UK, ASME Paper No. 81-DET-39

**Key Words:** Mathematical models, Machine tools, Structural modification effects, Natural frequencies, Mode shapes, Damping coefficients

A technique is developed for determining the modal parameters (i.e. resonant frequencies, damping factors and modal shapes) from experimental receptance plots. From these, the equations of motion relating to the system are derived and used to predict the effect of changes in the structure of the dynamic characteristics of the system.

**82-268**

**Machine Tool Structure and Cutting Process Using Bivariate Time Series Models**

A.N. Shuaib, S.M. Wu, and S.G. Kapoor

Univ. of Wisconsin-Madison, Madison, WI, ASME Paper No. 80-WA/Prod-27

**Key Words:** Machine tools, Cutting

A bivariate time series ARMAV model is developed from the cutting torque and relative vibrations signals to represent a closed-loop machining process system. Explicit expressions for the transfer functions of the machine tool structure and the cutting process are derived from the bivariate models.

**MATERIALS HANDLING EQUIPMENT**

(See No. 554)

**STRUCTURAL SYSTEMS**

**BRIDGES**

**82-269**

**Wave Induced Vibrations of Continuous Floating Structures**

C. Georgiadis

Ph.D. Thesis, Univ. of Washington, 118 pp (1981)  
UM8121197

**Key Words:** Floating structures, Pontoon bridges, Water waves, Fluid-induced excitation, Hydrodynamic excitation, Computer programs

The following subjects concerning the response of continuous floating structures have been worked out in this thesis: Hydrodynamic forces on a continuous floating structure. The effect of the three-dimensional sea state and structure modes of oscillation have been taken into account. Response of a continuous floating structure to long-crested, oblique waves. Response of a continuous floating structure to short-crested waves. Response of floating bridges and breakwaters to boat wakes. Computer programs have been developed to implement the above ideas and to give a complete design support for the above mentioned structures.

**82-270**

**Impact and Fatigue in Open Deck Railway Truss Bridges**

A. Wiriyachai

Ph.D. Thesis, Illinois Inst. of Tech., 157 pp (1980)  
UM 8112430

**Key Words:** Trusses, Bridges, Railroads, Fatigue life

The purpose of this study was to investigate various factors affecting the impact values and fatigue lives of various members in open deck railway truss bridges. The vehicle model used in the study has three degrees of freedom: bounce, pitch and roll.

**82-271**

**Analysis and Prevention of Suspension Bridge Flutter in Construction**

F. Brancaloni and D.M. Brotton

Istituto di Scienza delle Costruzioni dell'Università di Roma, Rome, Italy, Earthquake Engrg. Struc. Dynam., 9 (5), pp 489-500 (Sept-Oct 1981) 13 figs, 1 table, 13 refs

**Key Words:** Bridges, Suspension bridges, Flutter, Vibration control

It is known that the maximum danger of flutter-type aerodynamic instability for suspension bridges occurs during the early erection phases of the deck. The effectiveness of two different provisional measures for increasing the instability critical windspeed in such conditions is evaluated for a long span suspension bridge with flat box stiffening girder.

## **BUILDINGS**

(Also see Nos. 276, 550)

### **82-272**

#### **Mean-Square Structural Response to Stationary Ground Acceleration**

M. Grigoriu

Cornell Univ., Ithaca, NY, ASCE J. Engrg. Mechanics Div., 107 (EM5), pp 969-986 (Oct 1981) 12 figs, 1 table, 16 refs

**Key Words:** Buildings, Nuclear power plants, Power plants (facilities), Ground motion, Random excitation, Statistical analysis, Time domain method

Second-moment statistics are obtained for modal and structural responses of linear structures with classical modes of vibration subjected to stationary input ground accelerations, during the steady-state period of motion. These statistics are found by analysis in the time-domain based on the theory of linear systems. Their determination involves only simple algebraic operations for piecewise linear input spectra. The approach, in general, for any ground or floor spectra can be approximated by a piecewise linear function. An asymmetric space structure and a planar shear frame are analyzed to illustrate applications of the proposed approach.

### **82-273**

#### **Investigation of the Seismic Resistance of Interior Building Partitions, Phase I**

R.W. Anderson, Y.-C. Lee, G. Savulian, B. Barclay, and G. Lee

Agbabian Associates, El Segundo, CA, Rept. No.

NSF/CEE-81006, 89 pp (Feb 1981)

PB81-210973

**Key Words:** Buildings, Walls, Multistory buildings, Seismic response

This study investigates the effective participation of wood-framed interior shear wall partitions when determining the ultimate resistance capacity of two- and three-story masonry apartment buildings to seismic loading. Load vs. deflection tests were performed on 8 ft by 8 ft wall panel specimens constructed of four different facing materials, including wood lath and plaster, gypsum lath and plaster, and gypsum wallboard with joints placed either horizontally or vertically. The wood lath and plaster construction was found to be significantly stronger and stiffer than the other three specimens.

### **82-274**

#### **Simple Model for Earthquake Response Studies of Torsionally Coupled Buildings**

C.L. Kan and A.K. Chopra

Peter Y.S. Pun & Assoc., Consulting Engrs., Hong Kong, China, ASCE J. Engrg. Mechanics Div., 107 (EM5), pp 935-951 (Oct 1981) 11 figs, 1 table, 7 refs

**Key Words:** Buildings, Torsional response, Coupled response, Seismic response

Simple models defined only in terms of overall system properties are developed to approximate the response of one-story buildings. A system with several resisting elements may be idealized as a single element system with the following properties: several parameters in the linearly elastic range of behavior are the same as for the multi-element system; and a single yield surface, circular in the normalized coordinate system, with yield shear and torque defined in terms of the corresponding properties of the multi-element system. The response of a single-element system defined in this manner is approximately representative of the inelastic response of a large class of multi-element systems. Consequently, the variety of building properties and plan layouts encountered in practice, which are too numerous for explicit consideration in studies of earthquake response of torsionally coupled buildings, can be effectively handled by a single element model.

### **82-275**

#### **Buckling and Vibrations of Spatial Building Structures**

R. Rosman

Pantovčak 135, Zagreb, Yugoslavia, *Engrg. Struc.*, 3 (4), pp 194-202 (Oct 1981) 7 figs, 4 tables, 6 refs

**Key Words:** Buildings, Fundamental frequency, Mode shapes

A simple hand method is developed for the determination of the fundamental buckling weight, the fundamental vibration period, and the corresponding mode shapes of a frequent type of contemporary building structure, the weight axis of which does not coincide with its stiffness axis. Moreover, the plane of the lateral load is determined, which produces a deformation corresponding to the buckling and vibration mode shapes. Typical examples illustrate the practical application of the method.

## FOUNDATIONS

(Also see Nos. 384, 408, 523)

**82-276**

### Effect of Waterproof Linings on the Seismic Response of a Building

C. Chesi and E. Mitsopoulou

Dept. of Struc. Engrg., Tech. Univ. of Milan, Milan, Italy, *Engrg. Struc.*, 3 (4), pp 203-209 (1981) 14 figs, 12 refs

**Key Words:** Foundations, Buildings, Seismic response

In the presence of a high water table or a deeply embedded foundation a waterproof lining is generally needed. If this lies between two plane surfaces of concrete, a severe earthquake is likely to provoke relative displacements. Thus the lining may break and displacements may be too large for complying with the requirements of pipes, tunnels or adjacent structures. A favorable result is also expected in the reduction of the structure's accelerations. The present paper deals with the evaluation of these relative displacements and of the acceleration reduction.

**82-277**

### Dynamic Response of Foundations with Arbitrary Geometries

H. Adeli, M.S. Hejazi, L.M. Keer, and S. Nemat-Nasser

Univ. of Tehran, Tehran, Iran, *ASCE J. Engrg. Mechanics Div.*, 107 (EM5), pp 953-967 (Oct 1981) 10 figs, 2 tables, 11 refs

**Key Words:** Foundations, Boundary value problems, Elastodynamic response

A procedure is developed for determining the dynamic response of an elastic half-space to the rigid body motion of an irregularly shaped foundation. The method is to subdivide the foundation into rectangular subregions and calculate the response for an equivalent circular subregion having a constant load. The load magnitude of the circular region is the same as for the rectangular region. Compliances are computed for foundation shapes that could be compared with the results of others. Accuracy and time for computation for these comparison examples were reasonably good.

**82-278**

### The Dynamics of a Rigid Foundation on the Surface of an Elastic Half-Space

H.R. Hamidzadeh-Eraghi and P. Grootenhuys

Dept. of Mech. Engrg., Imperial College of Science and Tech., London, UK, *Earthquake Engrg. Struc. Dynam.*, 9 (5), pp 505-515 (Sept-Oct 1981) 12 figs, 1 table, 26 refs

**Key Words:** Foundations, Half-space, Harmonic excitation, Point source excitation

The response of a rigid rectangular foundation block resting on an elastic half-space has been determined by considering first the displacement functions for any position on the surface of an unloaded half-space due to a harmonic point force. The influence of the foundation has been taken into account by assuming a relaxed condition at the interface, i.e. a uniform displacement under the foundation and that the sum of the point forces must equal the total applied force. The three motions of vertical, horizontal and rocking have been considered and numerical values for the in-phase and the quadrature components of the displacement functions are presented for a Poisson's ratio of 0.25. The effect of the mass and inertia of the foundation can be allowed for by an impedance matching technique. Response curves and non-dimensional resonant frequency curves are given for a square and a rectangular foundation for different mass and inertia ratios and for several values of Poisson's ratio. These curves are for design purposes and are an addition to similar published curves for circular values of Poisson's ratio. These curves are for design purposes and are an addition to similar published curves for circular and infinitely long rectangular foundations. Some of the calculated results have been verified by a laboratory experiment.

**82-279**

### Layered Soil-Pile-Structure Dynamic Interaction

H. Takemiya and Y. Yamada

Dept. of Civil Engrg., Okayama Univ., Okayama, Japan, Earthquake Engrg. Struc. Dynam., 9 (5), pp 437-457 (Sept-Oct 1981) 10 figs, 2 tables, 23 refs

**Key Words:** Interaction: soil-structure, Layered materials, Pile foundations, Harmonic excitation, Bridges, Piers

This paper is concerned with the dynamic interaction between soil, pile, and structure when subjected to harmonic excitation at the base rock level. The structure to be analyzed is an isolated tall bridge pier with deep group pile foundation. The dynamic substructure approach is taken, dealing first with the pile-footing substructure and the pier superstructure independently; and then integrating these at the interface. Since the soil profile is multi-layered, the transfer matrix scheme is applied to extend the relevant continuum solution proposed by earlier researchers for pile analysis in a homogeneous viscoelastic medium. Using a numerical example, the importance of the soil layer vibration modes which exert forces on the pile varying along the pile length is pointed out together with the soil-structure inertial interaction in the structural response. The latter concerns the dynamic characteristic of the complete system whereas the former relates the driving force to it. Also examined is the applicability of the approximate soil reaction based on the plane strain assumption, which simplifies the formulation and requires much less computing time in the response analysis.

**82-280**  
**Finite Element Analysis of Soil-Sheet Pile Interaction**  
D.W. Nyby  
Ph.D. Thesis, Utah State Univ., 232 pp (1981)  
UM 8120717

**Key Words:** Interaction: soil-structure, Pile structures, Finite element technique

The purpose of this study was to develop a finite-element model which could accurately and economically model soil-sheet pile structures. To this end, a two-dimensional, finite element model was developed. The model was then used to analyze cantilever and anchored sheet pile walls. The finite element model includes "transition" and interface elements. The transition element has the capability of conforming to the displaced shape of the sheet pile elements on one side and soil elements on the other sides. The interface element models the frictional resistance between the soil and the sheet pile. The soil is modeled using nonlinear constitutive relations. These relations are used for both the "transition" elements and the bilinear elements. The economy of the finite element model was increased in two ways. Closed-form integration was used to reduce the computational effort and an equation solver was used which takes advantage of the banded, symmetric, and positive-definite characteristics of the global stiffness matrix.

**82-281**  
**Soil Set-Up Due to Pile Driving**

W.T. Ayoub  
Ph.D. Thesis, School of Engrg., Tulane Univ.  
UM 8117697

**Key Words:** Pile driving, Soil mechanics

Until recently, predicting the increase in soil resistance during pile driving due to short or lengthy delays was unfeasible. It has often relied on experience and judgment. Estimating the hammer efficiency for theoretical wave equation studies was disputable. Dynamic measurements performed on piles during pile driving produced a wide varying range of unexplainable efficiency correlations. From fifteen actual platform case studies comprising over eighty piles, design curves to estimate the average increase in unit friction and the ratio of average increase in unit skin friction to average unit adhesion at the resumption of pile driving as a function of time and depth are provided. A new concept that explains the variation in dynamic measurement results is also provided. A new theoretical method to construct the soil resistance during pile driving versus blows/foot curve is included.

## ROADS AND TRACKS

**82-282**  
**Measured Pavement Response to Transient Aircraft Loadings**  
T.D. White  
Ph.D. Thesis, Purdue Univ., 243 pp (1981)  
UM 8123723

**Key Words:** Aircraft landing areas, Pavements, Taxiing effects

A testing program was designed and undertaken to collect pavement deformation response to aircraft traffic. Linear variable differential transducers (LVDT's) were installed in an active taxiway at Kirtland Air Force Base, Albuquerque, New Mexico. The LVDT's were attached to reference rods anchored at 16, 36, 120, and 209 in. Results were basic pavement responses, information on how pavement layers accommodate dynamic loads, as well as data to compare vertical deformations predicted by a theoretical model.

## CONSTRUCTION EQUIPMENT

**82-283**  
**Modelling the Combine Harvester**  
D.W. Campbell

Ph.D. Thesis, The Univ. of Saskatchewan, Canada (1980)

**Key Words:** Agricultural machinery, Mathematical models, Lumped parameter method

This thesis documents the development of a dynamic, lumped-parameter, computer model of a conventional combine harvester. Although considerable research has taken place on the steady state performance of individual combine components, very few studies have considered the combine dynamics. It was the need to better understand the overall combine harvester dynamics that prompted the development of this computer model. A number of key combine variables were dynamically measured and recorded during actual field tests using a conventional combine harvester. The measured input feedrate was used as the model input and the calculated outputs were compared to the actual measured outputs. This allowed the combine model equations to be consecutively modified until the statistical output errors were minimized to predetermined acceptable levels.

**82-284**

**Contribution to Calculations on Forces and Displacement of Randomly Traveling Cranes with Special Consideration of Elastic Supports, Construction Irregularities and the Nonlinear Frictional Connection-Slippage Law**

G. Wagner

Technische Hochschule, Darmstadt, Fed. Rep. Germany, Ph.D. Thesis, 98 pp (1980)

(In German)

PB81-210585

**Key Words:** Cranes (hoists), Supports, Force coefficients, Displacement analysis

The conventional methods for calculating forces on crane support and rail during crane operation are unsuitable for inclusion in a general crane static calculating program. In this study the descriptive equations for the actions, inertia, travel and starting travel are established and adapted to a nonlinear equation system, taking into account the essential limiting quantities and a nonlinear frictional connection-slippage law for random, elastic crane supports. In considering support elasticity, reference is made to results calculated with a finite elements program: forces and displacement on the traveling wheels and guide elements as the result of uniform pre-straining and uniform loads on the traveling wheels and the guide elements. The solution of the nonlinear equation system is dealt with in the calculating program by a modified Newton procedure which operates with the aid of algorithms to optimize band width and to solve linear equations systems with a band matrix. The starting

values of the Newton procedure are obtained by an automated precalculation. Changes in the equations of the system are carried out automatically. Possible uses are demonstrated with three examples. The correctness of the results can be easily verified through a check of force equilibriums and the geometry of the travel involved.

## **PRESSURE VESSELS**

(See No. 395)

## **POWER PLANTS**

(Also see Nos. 343, 352, 353, 369, 408, 497, 513)

**82-285**

**Seismic Design Margin Evaluation of Systems and Equipment Required for Safe Shutdown of North Anna, Units 1 and 2, Following an SSE (Safe-Shutdown Earthquake) Event**

K.D. Desai

Office of Nuclear Reactor Regulation, Nuclear Regulatory Commission, Washington, DC, Technical Rept., 56 pp (June 1981)

NUREG-0792

**Key Words:** Power plants (facilities), Nuclear power plants, Nuclear reactors, Seismic design

The Advisory Committee on Reactor Safeguards recommended that the NRC staff review in detail the capability and available seismic design margin of fluid systems and equipment used in North Anna, Units 1 and 2 to achieve safe shutdown following a site-design safe-shutdown earthquake (SSE). The staff conducted a series of plant visits and meetings with the licensee to view and discuss the seismic design methodology used for systems, equipment and their supports. The report is a description and evaluation of the seismic design criteria, design conservatisms and seismic design margin for North Anna, Units 1 and 2.

**82-286**

**Seismic Review of the Oyster Creek Nuclear Power Plant as a Part of the Systematic Evaluation Program**

R.C. Murray, T.A. Nelson, S.M. Ma, and J.D. Stevenson

Lawrence Livermore Natl. Lab., CA, Rept. No. UCRL-53018, 172 pp (Apr 1981)

NUREG/CR-1981)

**Key Words:** Power plants (facilities), Nuclear power plants, Seismic response

A limited seismic reassessment of the Oyster Creek Nuclear Power Plant was performed by the Lawrence Livermore National Laboratory (LLNL) for the U.S. Nuclear Regulatory Commission (NRC) as part of the Systematic Evaluation Program (SEP). The reassessment focused generally on the reactor coolant pressure boundary and on those systems and components necessary to shut down the reactor safely and maintain it in a safe shutdown condition following a postulated earthquake characterized by a peak horizontal ground acceleration of 0.22 g. Unlike a comprehensive design analysis, the reassessment was limited to structures and components deemed representative of generic classes. Conclusions and recommendations about the ability of selected structures, equipment, and piping to withstand the postulated earthquake are presented.

**82-287**

**Realistic Seismic Design Margins of Pumps, Valves, and Piping**

E.C. Rodabaugh and K.D. Desai

Oak Ridge Natl. Lab., TN, Rept. No. ORNL/SUB-2913/11, 108 pp (June 1981)  
NUREG/CR-2137

**Key Words:** Power plants (facilities), Nuclear power plants, Pumps, Valves, Pipes (tubes), Supports, Seismic design

Seismic design margins indicate the adequacy for earthquake resistance of pumps, valves, piping and their supports used in nuclear power plants. The margins that exist with the allowable stresses given in applicable codes and standards are reviewed in this report. Nuclear industry practice with respect to concrete expansion anchor bolts and operability of pumps and valves are also reviewed. Examples of specific applications are included to illustrate the significant seismic design margins which are present in the systems and equipment in nuclear power plants.

**82-288**

**Loss of One Rotor Blade from Wind Power Turbine**

B. Akesson and S. Sandstrom

Div. of Solid Mechanics, Chalmers Univ. of Technology, Gothenburg, Sweden, Chalmers Tekniska Hogskola, Hållfasthetslära, Skrift F65, 41 pp (Oct 1980) 5 figs

**Key Words:** Turbines, Wind turbines, Design techniques, Towers, Foundations, Blade loss dynamics

The design of full-scale wind power turbines equipped with 2-3 MW electrical generators is described. This plant is a free-standing reinforced concrete tower (prestressed) on a heavy concrete foundation resting directly on the local bedrock (limestone). The material of its two-blade rotor is a carbon steel. The possibility of a sudden loss of one blade is foreseen in the design of the foundation and the tower.

## OFF-SHORE STRUCTURES

**82-289**

**Response Spectrum Techniques for Three-Component Earthquake Design**

S.A. Anagnostopoulos

Shell Oil Co., Houston, TX, Earthquake Engrg. Struc. Dynam., 9 (5), pp 459-476 (Sept-Oct 1981) 5 figs, 7 tables, 23 refs

**Key Words:** Off-shore structures, Drilling platforms, Seismic design, Seismic response spectra, Response spectra

An evaluation is made of response spectrum techniques as applied to seismic analysis and design of steel template off-shore platforms. Such structures are designed as braced space frames for several loading conditions, including the simultaneous action of three earthquake components. Base shears as well as gross forces and combined stresses in members of three different platforms are computed for 30 real, three-component earthquakes and response spectrum predictions, obtained by several modal-spatial combination methods, are compared to time history solutions. Results are presented in the form of error statistics. The three approximations examined are: combination of modes for one component input, combination of the three partial responses to obtain estimates of total response, and combination of gross forces to derive maximum design stresses at a section. Attention is focused on corner piles because these are among the most heavily penalized members by three-component excitations. It is shown that commonly used spatial combination rules may underestimate gross forces in design controlling corner members by 15-30 per cent on the average. This is attributed to correlations between motion components that create additive effects along certain directions. Typical estimates of combined stresses, however, are found to be slightly conservative.

**82-290**

**Extreme and Fatigue Response of Offshore Platforms Due to Three-Dimensional Stochastic Wave Fields**

R. Sigbjörnsson

Engrg. Res. Inst., Univ. of Iceland, Reykjavik, Iceland, Engrg. Struc., 3 (4), pp 219-224 (Oct 1981) 5 figs, 31 refs

**Key Words:** Off-shore structures, Drilling platforms, Water waves, Fatigue life, Stochastic processes

This paper deals with stochastic aspects of wave induced vibrations of fixed offshore platforms with view towards probabilistic design. This includes stochastic treatment of ocean waves, wave loading and structural response processes, emphasizing predictions of extremes and fatigue. The load effects of short crested wave fields are exemplified.

Dynamic Science, Inc., Phoenix, AZ, Rept. No. 3108-80-178, DOT-HS-805 867, 193 pp (Feb 1981) PB81-211187

**Key Words:** Collision research (automotive), Experimental safety vehicles, Crashworthiness, Anthropomorphic dummies

The report presents the results of an 86.52 mph Frontal Aligned Impact crash test between the Minicars RSV M5-11 and a production 1979 Dodge Challenger. The objective of this test was to obtain data to evaluate the crashworthiness of the Minicars RSV by providing a comparison between the occupant protection capability of the Minicars RSV and a production car in a frontal collision mode.

## VEHICLE SYSTEMS

### GROUND VEHICLES

(Also see Nos. 349, 356, 552, 553)

**82-291**

#### **Traffic Noise Control by Using a Biological System Barrier**

J.-Y. Lee

Ph.D. Thesis, North Carolina State Univ. at Raleigh, 232 pp (1980)

UM 8114596

**Key Words:** Traffic noise, Noise barriers, Trees (plants)

The field experimentations have been surveyed to study the potential of vegetation for sound abatement. They show that a very dense properly placed shrub barrier has the most effective results. Sound attenuations from 3 to 5 dBA are common with a single row, very dense vegetation barrier, the difference depending upon the variety of shrubbery. An absorption and reflection test was developed based on the mathematical model of sound wave propagation through the vegetation layer to estimate the acoustic characteristics, absorptivity and reflectivity, of vegetation. The frequency analysis is included.

**82-292**

#### **Minicars Research Safety Vehicle to 1979 Dodge Challenger Crash Test Report - Frontal Aligned Impact at 86.52 MPH Closing Speed**

R. Bacynski, T. Bjork, and S. Davis

**82-293**

#### **Results of a 30 Degree Angled Barrier Crash Test on the Calspan RSV (Research Safety Vehicle) Conducted in England**

N. Johnson and S. Davis

Dynamic Science, Inc., Phoenix, AZ, Rept. No. 6079-80-195A, DOT-HS-805 861, 126 pp (Feb 1981) PB81-203200

**Key Words:** Collision research (automotive), Guard rails, Experimental safety vehicles, Experimental test data

The report presents the results of a 30 deg. angled barrier frontal impact test on the Calspan RSV No. 5. The impact velocity was 37.5 mph. The test was conducted by the Motor Industry Research Association, under the direction of the Transport and Road Research Laboratory, in Nuneaton, England. The crash test evaluated the structural integrity and response of its two dummy occupants, in a 30 deg. angled barrier crash.

**82-294**

#### **Evaluation of Passive Belts for Different Size Occupants**

N.J. DeLeys

Calspan Corp., Buffalo, NY, Rept. No. CALSPAN-6407-V-1, DOT-HS-805 853, 334 pp (Apr 1980) PB81-210767

**Key Words:** Seat belts, Automobile seat belts, Safety restraint systems, Collision research (automotive)

The report presents findings of a combined analytical and experimental research program to: determine the effect of

independent variation of the vertical and longitudinal position of the upper anchor point of the Volkswagen Rabbit passive belt on the performance of the restraint system for occupants ranging in size from a 6 year old child to a 95th percentile adult male; and to design and develop a vertically adjustable upper anchorage for the VW passive belt and evaluate the performance in impact sled tests. The data indicate that at least for belt crossing angles near the lower end of the range permitted by the comfort zone, the allowed position of the belt is too low and increases the likelihood of loading the lower abdomen due to occupants rolling over the belt.

**82-295**

**A Comparison of the Stability and Curving Performance of Radial and Conventional Rail Vehicle Trucks**

D. Horak, C.E. Bell, and J.K. Hedrick  
M.I.T. Vehicle Dynamics Lab., Cambridge, MA, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 191-200 (Sept 1981) 14 figs, 2 tables, 12 refs

**Key Words:** Railroad trains, Interaction: rail-wheel, Stability, Cornering effects

This paper compares the lateral stability and steady-state curving performance of radial and conventional rail vehicle trucks. The radial truck has two unique features: it allows direct elastic coupling between the wheelsets and it allows greater total truck shear stiffness for a given bending stiffness. It is shown that the first property allows the radial truck to achieve up to a 40 percent higher critical speed than the conventional truck for equivalent truck total shear and bending stiffness since the direct coupling between the wheelsets allows decoupling of the truck mass from the hunting wheelset masses. The second feature, i.e., greater shear stiffness capability, allows the radial truck to have improved wear properties during the negotiation of tight curves. It is shown that the high shear stiffness property combined with a low bending stiffness reduces the lateral flange force and wheelset angle of attack during flange contact. It is concluded that for routes where the majority of curves are less than 4 deg (greater than 400 m radius) the truck optimized for off-flange performance should have intermediate values of shear stiffness, bending stiffness, and conicity.

**82-296**

**Influence of Restoring Torque Between Truck and Car-Body on the Transversal Stability of a Railway Car at Seven, Seventeen and Nine Degrees of Freedom**

J. Richard and R. Joly

Université de Paris, France, ASME Paper No. 81-DET-41

**Key Words:** Railroad trains, Hunting motion, Restoring factors, Critical speeds

By considering the results of the impact of the nonlinear counter-hunting moment established from the study of a bogie, the authors have established the equation system of a fully equipped vehicle with 17 degrees of freedom. The critical speeds of the new equation system have been studied and the results compared with those obtained before.

**82-297**

**Wind Tunnel Tests of Trailer and Container Models. Determination of the Independent Influence of Height and Gap Spacings and Trailer Undercarriage Shielding on Aerodynamic Forces Occurring during Railroad Transport**

A.G. Hammitt

Hammitt (Andrew G.) Associates, Rancho Palos Verdes, CA, Rept. No. AGH-12-101-80, FRA/ORD-80/51, 92 pp (Mar 1980)  
PB81-210734

**Key Words:** Rail transportation, Freight cars, Trailers, Containers, Aerodynamic loads, Wind tunnel tests

A series of wind tunnel tests have been run on scale model trains of 40 ft. containers and trailers. The models were 1/43 scale. A train of five models was used with forces and moments measured on the center model. A variety of spaces were used between the models. The height of the container models was varied and the undercarriage of the trailers was protected with shields of different heights. These tests are the latest in a series designed to determine the aerodynamic forces on containers and trailers on flatcars. This series provides additional information on the effect of different container block height and gap spacings and the effect of spacing on the forces on trailers with different amounts of shielding up to large values of yaw angle.

**82-298**

**Experimental Investigation of Freight Car Lateral Dynamics**

R.H. Fries, N.K. Cooperrider, and E.H. Law  
Dept. of Mech. Engrg., Arizona State Univ., Tempe, AZ, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 201-210 (Sept 1981) 20 figs, 3 tables, 12 refs

**Key Words:** Railroad trains, Freight cars, Hunting motion, Natural frequencies

Field tests and accompanying data analysis to characterize the stable and hunting behavior of freight cars are discussed. These tests confirmed the fundamentally nonlinear nature of the conventional freight car. The hunting performance of an open hopper car is described by speed ranges in which intermittent hunting occurs. At speeds above the intermittent hunting speed ranges, hunting always occurs, and at speeds below these ranges, hunting does not occur. Results of evaluating the stability of the freight car in terms of the natural frequency and damping ratio of the least-damped vibration mode are presented. Anomalies in these results indicate that the damping ratio may not be an adequate stability measure for this nonlinear system. Root-mean-square values of significant vehicle motions are presented for the entire range of vehicle test speeds.

**82-299**

**Dynamic Response of Freight Vehicle Systems - A Performance Characterization**

P.V. Ramachandran, M.M. El Madany, and N.T. Tsai  
Wyle Laboratories, Colorado Springs, CO, ASME  
Paper No. 81-RT-4

**Key Words:** Articulated vehicles, Trucks, Freight cars, Cornering effects, Ride dynamics

This paper presents the results of performance characteristics of modern truck designs. The dynamic response of the conventional three-piece freight car trucks is discussed in detail, including the analysis of and results from field test data, and the analytic models, their verification against test data, and the use of simulated data obtained through the use of the models. A comprehensive picture of the dynamic response characteristics of the three-piece freight car truck is presented by considering four distinct and inclusive performance regimes, namely lateral stability, trackability, curve negotiation and ride quality.

**82-300**

**Dynamic Analysis of High Speed Rocket Sleds**

V.A. Tischler, V.B. Venkayya, and A.N. Palazotta  
Air Force Wright Aeronautical Lab., Dayton, OH,  
ASME Paper No. 81-DET-42

**Key Words:** Rocket sleds, Surface roughness, Stiffness coefficients, Parametric response

The rail roughness profile and the slipper stiffnesses are the important factors in determining the forcing function in the dynamic analysis of high speed rocket sleds. A parametric study involving a variation in the rail roughness profile and the slipper stiffnesses was performed.

**SHIPS**

(Also see Nos. 338, 393)

**82-301**

**Analysis of Motions of a Catamaran in Arbitrary Heading Waves**

F. Sun

Marine Design and Res. Inst. of China, Shanghai, China, J. Energy Resources Tech., Trans. ASME, 103 (3), pp 219-230 (Sept 1981) 2 figs, 13 refs

**Key Words:** Boats, Hydrodynamic excitation, Water waves

This paper analyzes the motions of a catamaran advancing at a constant speed in arbitrary heading waves. The mathematical expressions of the hydrodynamic coefficients and exciting forces are derived. These mathematical expressions apply not only to catamaran, but also to monohull, and can be extended to multihull. In analyzing the hydrodynamic and exciting forces, the hydrodynamic interactions between the two hulls are considered in addition to the effect of forward speed and aftermost section. These hydrodynamic interactions should not be neglected for the motions of catamaran.

**82-302**

**Environmental Conditions for Shipboard Hardware**

R.H. Chalmers

Naval Ocean Systems Ctr., J. Environ. Sci., pp 13-22 (Sept/Oct 1981) 17 figs, 3 tables, 23 refs

**Key Words:** Shipboard equipment response, Environmental effects, Testing techniques, Experimental test data

Reliability of equipment installed in Navy ships in the past has not compared favorably with reliability of the same equipment measured in laboratory tests. Among the many reasons believed contributing to the poor correlation was lack of environmental realism in the laboratory tests. It was the purpose of this task to provide environmental profiles for use in laboratory reliability testing the variations of which temperature, humidity, shock, and vibration were linked to variations which would be encountered on a typical Navy ship prosecuting a typical Navy mission.

**82-303**

**Some Memorable Breakdowns and Resulting Improvements**

T.W. Bunyan

Pilgrim Engrg. Developments Ltd., UK, Inst. of Marine Engrs., Trans. (TM), 93, Paper 5 (1981) 7 figs, 1 table, 8 refs

**Key Words:** Ship hulls, Bearings

Some interesting hull and machinery problems in ships are discussed. Trouble shooting, redesign and improved construction with particular reference to vibration and bearings are discussed.

**82-304**

**On the Dynamics of Ships in Heavy Seas**

R.E.D. Bishop and W.G. Price

Dept. of Mech. Engrg., Univ. College London, UK, IMechE Proc., 195, pp 175-187 (June 1981) 13 figs, 18 refs

**Key Words:** Ships, Water waves, Narrow band excitation

When a ship encounters waves, it moves bodily and it distorts. The structure being elastic and the waves being random, this behavior is in the nature of a narrow-band response. A systematic study of linear ship structural dynamics in which this standpoint is adopted was started in University College London about ten years ago and an attempt is made here to explain the present position. Far from putting a largely unnecessary gloss on traditional techniques of naval architecture, this approach to ship dynamics appears to promise much greater insight into ship behavior at a time when apparently well found and competently handled ships continue to be lost in the open sea.

**82-305**

**Vibrations Caused by Ship Traffic on an Ice-Covered Waterway**

F.D. Haynes and M. Maeaetaenen

Cold Regions Reg. and Engrg. Lab., Hanover, NH, Rept. No. CRREL-81-5, 37 pp (Apr 1981) AD-A101 541

**Key Words:** Ships, Ice breakers (ships), Ice, Vibration excitation

Vibrations have been felt on shore along the St. Marys River in Michigan during the passage of ships through ice. Vibration measurements were made on a ship, on the ice, on the shore, and on buildings along the shore. Vibration levels in 1979 were about an order of magnitude lower than levels that would cause damage to building walls.

**82-306**

**Vorticity Transport Integral Concept for Determining Wave Forces on Submerged Bodies**

T.E. Horton and M.J. Feifarek

Univ. of Mississippi, University, MS, J. Hydronautics, 15 (1-4), pp 34-38 (Dec 1981) 5 figs, 4 refs

**Key Words:** Submerged structures, Underwater structures, Water waves

The vorticity transport integral, an analytical procedure that is well suited to determining the wave forces on bodies and structural elements in a marine environment, is discussed. The concept can be applied to any unsteady flow; however, it is especially suited to the treatment of flows associated with ocean waves in which an object experiences complete flow reversal with wake motion confined to the vicinity of the body.

**AIRCRAFT**

(Also see Nos. 265, 282, 335, 342, 345, 458, 495, 531, 535, 541)

**82-307**

**Diagnostic Experiments on Supersonic Jet Noise**

D.K. McLaughlin

School of Mech. and Aerospace Engrg., Oklahoma State Univ., Stillwater, OK, Rept. No. NASA-CR-164348, 58 pp (Apr 30, 1981) N81-24856

**Key Words:** Aircraft noise, Jet noise, Supersonic frequencies, Computer programs

Experiments and computations on the flowfield and radiated noise of supersonic model jets are discussed. The shock associated noise produced by large scale instabilities in under-expanded supersonic jets, the nonlinear propagation distortion phenomenon in the noise radiated by supersonic model jets, and computations of instability evolution and radiated noise using the LSNOIS computer code are addressed.

82-308

**Upper Surface Blowing Noise of the NASA Ames Quiet Short-Haul Research Aircraft**

A.J. Bohn and M.D. Shovlin

Boeing Commercial Airplane Co., Seattle, WA, J. Aircraft, 18 (10), pp 826-832 (Oct 1981) 17 figs, 7 refs

**Key Words:** Aircraft, Noise generation, Noise reduction

An experimental study of the propulsive-lift noise of the NASA Ames quiet short-haul research aircraft (QSRA) is described. Comparisons are made of measured QSRA fly-over noise and model propulsive-lift noise data available in references. Developmental tests of trailing-edge treatments were conducted using sawtooth-shaped and porous USB flap trailing-edge extensions. Small-scale parametric tests were conducted to determine noise reduction/design relationships. Full-scale static runup and flight tests were conducted with the QSRA to evaluate edge treatments under flight conditions. Noise reductions of 2-3 dB were achieved over a wide range of frequency and directivity angles in static and flight tests of the QSRA.

82-309

**Noise Abatement Technology Options for Conventional Turboprop Airplanes**

W.J. Galloway and J.F. Wilby

Bolt, Beranek and Newman, Inc., Canoga Park, CA, Rept. No. BBN-4220, FAA/EE-80-19, 115 pp (June 1981)

AD-A101 828

**Key Words:** Aircraft, Noise reduction

The practical application of noise control technology to new and derivative conventional turboprop airplanes likely to come into service in the 1980's has been analyzed with a view to determining noise control cost/benefits. The analysis identifies feasible noise control methods, applies them to four study airplanes, and presents the noise reductions in terms of the equivalent perceived noise level at takeoff, sideline and approach locations, and the effect on the area within selected EPNL contours.

82-310

**Prediction of Forces and Moments on Finned Bodies at High Angle of Attack in Transonic Flow**

W.L. Oberkamp

Sandia Natl. Labs., Albuquerque, NM, 73 pp (Apr 1981)

SAND-80-2380

**Key Words:** Aircraft, Aerodynamic loads

This report describes a theoretical method for the prediction of fin forces and moments on bodies at high angle of attack in subsonic and transonic flow. The body is assumed to be a circular cylinder with cruciform fins (or wings) or arbitrary planform. The body can have an arbitrary roll (or bank) angle, and each fin can have individual control deflection. The method combines a body vortex flow model and lifting surface theory to predict the normal force distribution over each fin surface. Extensive comparisons are made between theory and experiment for various planform fins. A description of the use of the computer program that implements the method is given.

82-311

**Prediction of Transonic Flutter for a Supercritical Wing by Modified Strip Analysis and Comparison with Experiment**

E.C. Yates, Jr., E.C. Wynne, M.G. Farmer, and R.N. Desmarais

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83126, 31 pp (May 1981) (Presented at the AIAA Dyn. Specialists Conf., Atlanta, Apr 9-10, 1981)

N81-25432

**Key Words:** Airfoils, Aircraft wings, Flutter

Use of a supercritical airfoil can adversely affect wing flutter speeds in the transonic range. As adequate theories for three dimensional unsteady transonic flow are not yet available, the modified strip analysis was used to predict the transonic flutter boundary for the supercritical wing. The steady state spanwise distributions of section lift curve slope and aerodynamic center, required as input for the flutter calculations, were obtained from pressure distributions. The calculated flutter boundary is in agreement with experiment in the subsonic range. In the transonic range, a transonic bucket is calculated which closely resembles the experimental one with regard to both shape and depth, but it occurs at about 0.04 Mach number lower than the experimental one.

82-312

**Measured Pressure Distributions and Shock Shapes on a Simple Delta Wing**

L.C. Squire

Cambridge Univ. Engrg. Dept., Cambridge, UK, Aeronaut. Quart., 32 (3), pp 188-198 (Aug 1981) 11 figs, 4 refs

**Key Words:** Aircraft wings, Shock response

This note presents the results of an experimental investigation of the flow over a simple delta wing designed for a Mach number of 3.5. Complete pressure distributions were measured for incidences of  $0^\circ$ ,  $10^\circ$  and  $20^\circ$  at Mach numbers of 2.5 and 3.5. A number of Schlieren photographs of the shock system around the wing were obtained at the same conditions and surface streamline patterns were studied at  $M = 3.5$ . The measurements were made to support numerical calculations which use this wing as a test case.

#### 82-313

##### **Final Design and Fabrication of an Active Control System for Flutter Suppression on a Supercritical Aeroelastic Research Wing**

G.E. Hodges and C.R. McGehee  
Boeing Military Airplane Co., Wichita, KS, Rept. No. NASA-CR-165714, D3-11536-1, 396 pp (June 1981)  
N81-27114

**Key Words:** Aircraft wings, Active flutter control

The final design and hardware fabrication was completed for an active control system capable of the required flutter suppression, compatible with and ready for installation in the NASA aeroelastic research wing number 1 (APW-1) on Firebee II drone flight test vehicle. The goal of providing an increase of 20 percent above the unaugmented vehicle flutter velocity but below the maximum operating condition at Mach 0.98 is exceeded by the final flutter suppression system. Results indicate that the flutter suppression system mechanical and electronic components are ready for installation on the DAST ARW-1 wing and BQM-34E/F drone fuselage.

#### 82-314

##### **Optimization of Fiber Reinforced Structures to Satisfy Aeroelastic Requirements**

C.S. Rudisill  
Clemson Univ., SC, Rept. No. NASA-CR-164536, 8 pp (1981)  
N81-27200

**Key Words:** Aircraft, Flutter, Minimum weight design

A numerical procedure was developed for minimizing the structural mass of an aircraft structure which must have a

specified minimum flutter velocity or divergence velocity. During the optimization process the arrangement of the structural members remains fixed, while the stiffness parameters of the structure are varied.

#### 82-315

##### **Wind-Tunnel Evaluation of NASA Developed Control Laws for Flutter Suppression on a DC-10 Derivative Wing**

I. Abel and J.R. Newsom  
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83143, AIAA-PAPER-81-0639, 14 pp (June 1981)  
N81-27548

**Key Words:** Aircraft wings, Flutter, Vibration control, Wind tunnel tests

Two flutter suppression control laws were synthesized, implemented, and tested on a low speed aeroelastic wing model of a DC-10 derivative. The methodology used to design the control laws is described. The effect of variations in gain and phase on the closed loop performance was measured and compared with analytical predictions. The analytical results are in good agreement with experimental data.

#### 82-316

##### **Comparison of Analysis and Flight Test Data for a Drone Aircraft with Active Flutter Suppression**

J.R. Newsom and A.S. Pototzky  
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83145, 12 pp (June 1981)  
N81-27547

**Key Words:** Aircraft, Flight test data, Active flutter control

A drone aircraft equipped with an active flutter suppression system is considered with emphasis on the comparison of modal damping and frequencies as a function of Mach number. Results are presented for both symmetric and anti-symmetric motion with flutter suppression off. Frequency response functions of the vehicle are presented from both flight test data and analysis. The mathematical models are included and existing analytical techniques are described as well as an alternative analytical technique for obtaining closed-loop results.

82-317

**Estimation of Flutter Boundary from Random Responses Due to Turbulence at Subcritical Speeds**

Y. Matsuzaki and Y. Ando

Natl. Aerospace Lab., Jindaiji, Chofu, Tokyo, Japan, J. Aircraft, 18, (10), pp 862-868 (Oct 1981) 5 figs, 2 tables, 25 refs

**Key Words:** Aircraft wings, Flutter, Turbulence, Random response

*This paper describes a new efficient technique for estimating the flutter or divergence boundary from responses of a model to wind tunnel turbulence. The boundary can be predicted without estimating or measuring the damping and frequencies of the aeroelastic modes. The orders and coefficients of both autoregressive and moving average parts of the process are determined with the aid of Akaike's estimation procedure. The technique has been applied with success to signals from a cantilever wing model tested in a low supersonic flow. Comparison between the actual and estimated flutter boundaries shows that an accurate estimation can be made from data obtained in a narrow range of the dynamic pressure which is sufficiently below the boundary.*

82-318

**Effects of Inhomogeneities in Atmospheric Turbulence on the Dynamic Response of an Aircraft**

G. Trevino

Del Mar College, Corpus Christi, TX, J. Aircraft, 18, (10), pp 844-848 (Oct 1981) 5 figs, 11 refs

**Key Words:** Aircraft, Turbulence, Power spectra, Periodic excitation

*The power-spectral density of the dynamic response of an aircraft to inhomogeneous turbulence is formulated. In order to facilitate the analysis of the response the inhomogeneous turbulence is decomposed into two parts -- a part whose statistics, viz. the scale and the intensity, are spatially constant and a part whose statistics are spatially varying. Numerical results are obtained for the cases of an airplane flying through turbulence whose intensity varies sinusoidally in space and an airplane flying through turbulence whose integral scale varies sinusoidally in space.*

82-319

**High-Alpha Aerodynamic Model Identification of T-2C Aircraft Using the EMB Method**

H.L. Stalford

Practical Sciences, Inc., Carlisle, MA, J. Aircraft, 18, (10), pp 801-809 (Oct 1981) 14 figs, 1 table, 14 refs

**Key Words:** Aircraft, System identification techniques

*The estimation-before-modeling (EBM) system identification method has been applied to actual high-alpha/beta flight data of the T-2C jet trainer aircraft. Eighteen maneuvers (600 s at 20 Hz) were processed by the two steps of the EBM technique. The estimated biases and scale factors of the measurements are presented. Comparisons between the wind-tunnel and the identified state and control derivatives are given. Comparisons between the predicted and the identified dynamic derivatives are presented. There is good agreement between the identified nonlinear model and the wind-tunnel model. Many (although not all) identified dynamic derivatives are in agreement with the prediction models except near stall or at high alpha.*

82-320

**Analytical Testing**

W.G. Flannelly, J.A. Fabunmi, and E.J. Nagy

Kaman Aerospace Corp., Bloomfield, CT, Rept. No. NASA-CR-3429, R-1614, 154 pp (May 1981) N81-23487

**Key Words:** Aircraft vibration, Structural modification effects

*Analytical methods for combining flight acceleration and strain data with shake test mobility data to predict the effects of structural changes on flight vibrations and strains are presented. This integration of structural dynamic analysis with flight performance is referred to as analytical testing. The objective of this methodology is to analytically estimate the results of flight testing contemplated structural changes with minimum flying and change trials. The category of changes to the aircraft includes mass, stiffness, absorbers, isolators, and active suppressors. Examples of applying the analytical testing methodology using flight test and shake test data measured on an AH-1G helicopter are included. The techniques and procedures for vibration testing and modal analysis are also described.*

82-321

**Development of a Correlated Finite Element Dynamic Model of a Complete Aero Engine**

R.A. Bellamy, J.C. Bennett, and S.T. Elston

Rolls-Royce Ltd., UK, ASME Paper No. 81-DE-74

**Key Words:** Aircraft engines, Finite element technique, Modal analysis, Vibration tests

This paper presents a particular case study in which a complete RB211-524 engine carcase and nacelle was modeled using the Rolls-Royce finite element system. This structure was also vibration tested in the laboratory using two independent modal analysis systems. Close correlation between theory and experiment is demonstrated, which gives confidence in the finite element method for prediction of the dynamic properties of a real engineering structure.

#### 82-322

##### **Analytical Prediction of Aerospace Vehicle Vibration Environments**

J.F. Wilby and A.G. Piersol

Bolt, Beranek and Newman, Inc., Canoga Park, CA, ASME Paper No. 81-DET-29

**Key Words:** Spacecraft, Space shuttles, Boundary layer excitation, Aircraft, Propeller induced excitation, Vibration response

Considerable attention has been given recently to the formulation and validation of analytical models for the prediction of aerospace vehicle vibration response to acoustic and fluctuating pressures. This paper summarizes the development of such analytical models for two applications, structural vibrations of the Space Shuttle orbiter vehicle due to broadband rocket noise and aerodynamic boundary layer turbulence, and structural vibrations of general aviation aircraft due to discrete frequency propeller and reciprocating engine exhaust noise.

#### 82-323

##### **Experimental Verification of Force Determination and Ground Flying on a Full-Scale Helicopter**

R. Jones, W.G. Flannelly, E.J. Nagy, and J.A. Fabunmi

Kaman Aerospace Corp., Bloomfield, CT, Rept. No. R-1625, USAAVRADCOM-TR-81-D-11, 165 pp (May 1981)  
AD-A100 182

**Key Words:** Helicopters, Aerodynamic loads

Force determination is a method of obtaining dynamic loads acting on a vehicle in flight. These loads were determined from measured fuselage responses obtained in flight

and calibration matrices obtained in a shake test. These forces obtained were verified by ground flying in a hanger and duplicated the responses obtained in flight.

#### 82-324

##### **Additional Noise Data on the Sr-3 Propeller**

J.H. Dittmar and R.J. Jeracki

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-81736, E-804, 16 pp (May 1981)  
N81-25767

**Key Words:** Propellers, Noise generation

The noise generated by supersonic-tip-speed propellers is investigated. An eight bladed propeller was tested in the Lewis 8- by 6-foot wind tunnel with conditions providing data in the subsonic operating region of the propeller. Directivity curves with an additional transducer position gave an indication of a lobe pattern for this propeller that was not previously observed. The present data at the aft-most position indicate that some reflections, possibly from the test rig support strut, may have affected the data taken previously.

#### 82-325

##### **Validation of Helicopter Noise Prediction Techniques**

G.P. Succi

Bolt, Beranek and Newman, Inc., Cambridge, MA, Rept. No. NASA-CR-165715, 75 pp (Apr 1981)  
N81-25768

**Key Words:** Helicopters, Noise prediction

The current techniques of helicopter rotor noise prediction attempt to describe the details of the noise field precisely and remove the empiricisms and restrictions inherent in previous methods. These techniques require detailed inputs of the rotor geometry, operating conditions, and blade surface pressure distribution. The purpose of this paper is to review those techniques in general and the Farassat/Nystrom analysis in particular. The predictions of the Farassat/Nystrom noise computer program, using both measured and calculated blade surface pressure data, are compared to measured noise level data.

#### 82-326

##### **Modal Analysis Using Helicopter Dynamic Test Data**

N. Giansante and N. Calapodas

Kaman Aerospace Corp., Bloomfield, CT, ASME  
Paper No. 81-DET-30

**Key Words:** Helicopters, Modal analysis, Natural frequencies,  
Mode shapes

A description is presented of experimental techniques for dynamic test data acquisition and analytical procedures for performing modal analysis. Modal analysis was applied to data acquired from dynamic test of the AH-1G helicopter airframe. Application of the methodology allowed accurate definition of the structure's natural frequencies, generalized modal parameters and complex mode shapes.

**82-327**

**Impact of Prediction Accuracy on Costs - Noise  
Technology Applications in Helicopters**

R.H. Spencer and H. Sternfield, Jr.  
Boeing Vertol Co., Philadelphia, PA, Rept. No.  
FAA/EE-80-5, AD-A083 955, 49 pp (June 1981)  
AD-A101 768

**Key Words:** Helicopter noise, Noise prediction

This study is an extension of the work reported in AD-A083 935, and considers the effect which uncertainties in the prediction and measurement of helicopter noise have on the development and operating costs.

**82-328**

**State of the Art and Statistical Aspects of Helicopter Fatigue Substantiation Procedures**

R. Noback  
Natl. Aerospace Lab., Amsterdam, The Netherlands,  
Rept. No. NLR-MP-80025-U, 24 pp (Aug 1980)  
N81-27087

**Key Words:** Helicopters, Fatigue life, Statistical analysis

The methods used to calculate the safe fatigue life of helicopter components are described. Flight loads are determined for the flight conditions and maneuvers of the mission profiles. The application of the Palmgren-Miner rule and mean load reduction techniques is described. Reduced S-N curve methods in which constant amplitude tests are carried out at various load levels until failure are presented together with the corresponding error analysis. Alternative statistical analyses are compared.

**82-329**

**Naval Architectural Considerations in the Design of a Helicopter**

J.C. Daidola, D.A. Graham, and B.B. Blake  
M. Rosenblatt & Son, Inc., New York, NY, J. Hydro-  
nautics, 15 (1-4), pp 25-29 (Dec 1981) 4 figs, 3  
tables, 19 refs

**Key Words:** Helicopters, Water waves, Impact response

Methods and procedures are given that have been adopted and/or developed to analyze helicopters with respect to survival at sea in case of an emergency ditching. The areas considered are intact and damaged stability, waterborne motions, and impact loads. Stability of the helicopter is analyzed by applying the criteria for ships and advanced vehicles of several ship classification societies and the U.S. Navy. In conclusion, it is shown that the existing theories and criteria for ship vehicle stability, motions, and impact loads can be applied to helicopters on the sea surface to obtain a measure of their survival capabilities, to develop design information for systems intended to be activated under such conditions, and to give pilots more information regarding operation in this mode.

**MISSILES AND SPACECRAFT**

(Also see No. 322)

**82-330**

**On the Non-Linear Vibrations of a Projectile**

R.C. Rath and S.M. Sharma  
Inst. of Armament Tech., Girinagar, Pune-25, India,  
Aeronaut. Quart., 32 (3), pp 228-242 (Aug 1981)  
6 figs, 2 tables, 7 refs

**Key Words:** Missiles, Oscillation

The Nonlinear Magnus effect on the nutational oscillations of a missile has been studied. In particular the existence of self-sustained vibrations has been proved. A numerical method is suggested to obtain the limit cycles wherever they exist.

**82-331**

**An Approximate Solution to Improve Computational Efficiency of Impedance-Type Payload Load Prediction**

C.W. White

Martin Marietta Aerospace, Denver, CO, Rept. No. NASA-CR-165719, MRC-80-654, 206 pp (July 1981)  
N81-27190

**Key Words:** Impedance technique, Frequency domain method, Time domain method, Spacecraft, Design procedures

The computational efficiency of the impedance type loads prediction method was studied. Three goals were addressed: devise a method to make the impedance method operate more efficiently in the computer; assess the accuracy and convenience of the method for determining the effect of design changes; and investigate the use of the method to identify design changes for reduction of payload loads. The method is suitable for calculation of dynamic response in either the frequency or time domain. It is concluded that: the choice of an orthogonal coordinate system will allow the impedance method to operate more efficiently in the computer; the approximate mode impedance technique is adequate for determining the effect of design changes, and is applicable for both statically determinate and statically indeterminate payload attachments; and beneficial design changes to reduce payload loads can be identified by the combined application of impedance techniques and energy distribution review techniques.

**82-332**

**Beat Frequency Interference Pattern Characteristics Study**

J.H. Ott and J.S. Rice

Novar Electronics Corp., Barberton, OH, Rept. No. NASA-CR-160958, 102 pp (Jan 20, 1981)  
N81-25280

**Key Words:** Beat frequency, Satellites

The frequency spectra and corresponding beat frequencies created by the relative motions between multiple solar power satellites due to solar wind, lunar gravity, etc. were analyzed. The results were derived mathematically and verified through computer simulation. Frequency spectra plots were computer generated.

## **BIOLOGICAL SYSTEMS**

### **HUMAN**

**82-333**

**Comparison of Loudness and Annoyance Models for Noise**

W.A. Olsen, B.J. Clark, and O. Carter  
NASA, Cleveland, OH, S/V, Sound Vib., 15 (9), pp 13-16 (Sept 1981) 3 figs, 2 tables, 10 refs

**Key Words:** Noise measurement, Rating, Human response

Noise comparisons and noise measurements would be simplified by the adoption of a simple uniform rating method, such as the A-weighted scale. For a wide variety of noise sources, ratings by the A-weighted scale, the perceived noise scale and a recent model by Howes are shown to be equivalent descriptions of the loudness levels. Tone corrections appear to be an added factor necessary to convert from loudness ratings to annoyance ratings.

**82-334**

**The Noise Attenuation of Weak Shock Waves by Ear Muffs**

E. Osmundsen and K. Gjaevenes

Inst. of Physics, Univ. of Oslo, Oslo 3, Norway, J. Sound Vib., 77 (3), pp 375-385 (Aug 8, 1981) 5 figs, 18 refs

**Key Words:** Noise reduction, Ears, Experimental test data, Test facilities

By means of measurements and theoretical considerations the use of an artificial head in the evaluation of the efficiency of ear muffs for attenuating weak shock waves was examined. The results indicate that an artificial head can be used for an objective evaluation of ear protectors provided the artificial head has the appropriate properties.

**82-335**

**Community Reaction to Impulse Noise: Initial Army Survey**

P.D. Schomer

Army Construction Engrg. Res. Lab., Champaign, IL, Rept. No. CERL-TR-N-100, 173 pp (June 1981)  
AD-A101 674

**Key Words:** Aircraft noise, Human response

This report gives the results of a noise-impact attitudinal survey done in the Fort Bragg/Fayetteville, NC, area. It shows that to the extent normal sources like airplanes fit an energy model (such as the day/night average sound level (DNL), impulse noise also fits an energy model.

# MECHANICAL COMPONENTS

## ABSORBERS AND ISOLATORS

(Also see Nos. 334, 352, 353, 414, 440)

82-336

### Vibration Characteristics of a Laser Heterodyne Spectrometer Tunable Diode Laser System Using a Mechanical Cooler Platform

J.J. Catherines and J.W. Schwartz

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-83129, 26 pp (Apr 1981)

N81-25361

**Key Words:** Lasers, Vibration isolation

The Langley Research Center redesigned the cooler test bed hardware for the refrigerator for the purpose of isolating the tunable diode laser (TDL) from the cold tip in a laser heterodyne spectrometer system. Deflection in the lateral and vertical directions were managed on the cold tip and on the TDL. Measurements were analyzed over the frequency range of 0.100 Hz. The results show that the TDL responds approximately one order of magnitude less than that of the cold tip. The redesign of the system provided for adequately isolating the TDL for future operation.

82-337

### Hydraulic Brake (Industrial Shock Absorber) (Hydraulische Bremseinrichtung (Industriestossdämpfer)

W. Winkler and M. Rieger

Forschungszentrum des Werkzeugmaschinenbaues im VEB Werkzeugmaschinenkombinat „Fritz Heckert“ Karl-Marx-Stadt, East Germany, Maschinenbautechnik, 7, pp 324-328 (1981) 11 figs, 2 refs

(In German)

**Key Words:** Shock absorbers, Conveyors, Brakes (motion arresters), Hydraulic equipment

The design, calculation, and application of industrial shock absorbers are described and the test results for braking force and the range of adjustment are given. A considerable reduction of the impact acceleration can be obtained by the use of an elastomer as percussive head.

82-338

### Single vs Dual Snubber Installations

A.T. Onesto

Energy Technology Engrg. Ctr., Canoga Park, CA, Rept. No. ETEC-TDR-80-12, 209 pp (May 1981) NUREG/CR-2032

**Key Words:** Snubbers (ships), Shock absorbers, Ships

The results of a test program to investigate the effects of snubber mismatch on system response and load sharing is presented. Test variables included input (sine or seismic), support configuration (single or dual), support type (rigid strut, mechanical snubber or hydraulic snubber) and end fitting clearance.

82-339

### Dynamic Restoring and Dissipative Parameters of Non-Linear Systems

K. Peleg

Technion, Israel Inst. of Tech., Haifa, Israel, Intl. J. Mech. Sci., 23 (10), pp 595-606 (1981) 8 figs, 1 table, 15 refs

**Key Words:** Machinery, Mountings, Isolators, Shock absorbers, Vibration isolators, Dissipation factor, Restoring factors

Elastometer vibration and shock absorbing machinery mountings and package cushioning cannot be accurately modeled as linear Voigt type systems, because most of them exhibit stiffening or softening elasticity in conjunction with friction and viscous damping. Improved accuracy may be achieved by a non-linear shock or vibration loaded model, incorporating linear with non-linear elasticity and combined Coulomb and viscous damping. Formulae of such a model are compiled whereby optimal cushioning systems and mounts in shock and vibration loading may be designed. The use of these formulae requires experimental evaluation of two pairs of restoring and dissipative parameters in shock and vibration loading. Equations and test procedures for evaluating these parameters by means of shock and vibration machine tests are presented, along with a detailed discussion of properties of hysteresis loops of non-linear single degree of freedom systems in shock and vibration loading. A special test jig is described comprising a non-linear system with adjustable non-linear elasticity as well as variable Coulomb and viscous damping.

82-340

### Main Rotor Six Degree-of-Freedom Isolation System Analysis

L.B. Eastman

Sikorsky Aircraft Div., United Technologies Corp.,  
Stratford, CT, Rept. No. NASA-CR-165665, SER-  
70471, 59 pp (Apr 1981)  
N81-25090

**Key Words:** Isolators, Rotors

The design requirements of the system have been defined and an isolator concept satisfies these requirements identified. Primary design objectives for the isolation system are 90% attenuation of all NP main rotor shaft loads at a weight penalty less than or equal to 1% of design gross weight. The configuration is sized for a UH-60A BLACK HAWK helicopter and its performance, risk, and system integration were evaluated through a series of parametric studies. Preliminary design was carried forward to insure that the design is practical and that the details of the integration of the isolator into the helicopter system are considered. Alternate ground and flight test demonstration programs necessary to verify the proposed isolator design are defined.

**82-341**

**Total Main Rotor Isolation System Analysis**

D.R. Halwes

Textron Bell Helicopter, Fort Worth, TX, Rept. No.  
NASA-CR-165667, 142 pp (June 1981)  
N81-27076

**Key Words:** Isolators, Rotors

The requirements for a preliminary design study and verification procedure for a total main rotor isolation system at n/rev are established. The system is developed and analyzed, and predesign drawings are created for an isolation system that achieves over 95 percent isolation of all six degrees of freedom.

**82-342**

**Application of a Flight Test and Data Analysis Technique to Flutter of a Drone Aircraft**

R.M. Bennett

NASA Langley Research Ctr., Hampton, VA, Rept.  
No. NASA-TM-83136, 12 pp (May 1981)  
N81-25066

**Key Words:** Active flutter control, Flutter, Aircraft, Modal analysis

Modal identification results presented were obtained from recent flight flutter tests of a drone vehicle with a research

wing (DAST ARW-1 for Drones for Aerodynamic and Structural Testing, Aeroelastic Research Wing-1). This vehicle is equipped with an active flutter suppression system (FSS). Frequency and damping of several modes are determined by a time domain modal analysis of the impulse response function obtained by Fourier transformations of data from fast swept sine wave excitation by the FSS control surface on the wing.

**82-343**

**Properties of Confined Concrete Subjected to Static and Dynamic Loads**

S.H. Ahmad

Ph.D. Thesis, Univ. of Illinois at Chicago Circle, 397  
pp (1981)  
UM 8120556

**Key Words:** Energy absorption, Concretes, Seismic design, Buildings, Nuclear reactor containment, Nuclear reactors

Reliable and accurate information on strength, failure mode, ductility and energy absorption capacity is required for the design of reinforced and prestressed concrete structures such as nuclear containment structures, reactor vessels, and for the development of new types of building construction such as coupled shear-wall frame system and shock absorbing first story concept, particularly for seismic loading conditions. If the basic constitutive relationships of the two major components (steel and concrete) of reinforced and prestressed concrete are known, then it would be possible using a computerized mathematical model to calculate ductility and other parameters for a wide variety of situations and combinations. The first objective of this investigation was to obtain accurate and reproducible complete stress-strain curves of unconfined and confined concrete subjected to uniaxial monotonic and cyclic compressive loads. The second objective of this investigation was to develop a constitutive law under multiaxial compressive loadings, for predicting the complete (ascending and descending portions) stress-strain curves. A simple experimental technique (concrete confined in steel tube) was developed to obtain the post peak behavior under cylindrical triaxial compressive loadings.

**82-344**

**Materials for Noise Control**

R. Prybutok

Specialty Composites Corp., SAE Paper No. 810859

**Key Words:** Absorbers (materials), Noise reduction, Trucks, Motor vehicles

New materials and applications are used to make heavy trucks quieter.

82-345

**Engine Isolation for Structural-Borne Interior Noise Reduction in a General Aviation Aircraft**

J.F. Unruh and D.C. Scheidt

Southwest Research Inst., San Antonio, TX, Rept. No. NASA-CR-3427, SWRI-02-4860, 164 pp (May 1981)

N81-25766

**Key Words:** Aircraft noise, Engine noise, Noise reduction, Vibration isolation

Engine vibration isolation for structural-borne interior noise reduction is investigated. A laboratory based test procedure to simulate engine induced structure-borne noise transmission, the testing of a range of candidate isolators for relative performance data, and the development of an analytical model of the transmission phenomena for isolator design evaluation are addressed. The isolator relative performance test data show that the elastomeric isolators do not appear to operate as single degree of freedom systems with respect to noise isolation.

82-346

**A Business Look at Duct Silencers**

J. Conway

Pilots Engrg., Tucker, GA, S/V, Sound Vib., 15 (9), pp 10-12 (Sept 1981) 2 figs, 3 tables, 3 refs

**Key Words:** Silencers, Ducts

A procedure for selecting duct silencers on the basis of their life cycle costs is presented. Costs considered include purchase, installation, depreciation, operation, maintenance and salvage.

82-347

**Design of Modal Control of Structures**

O. Vilnay

Dept. of Civil and Struct. Engrg., Univ. College, P.O. Box 97, Cardiff, CF 11XP, UK, ASCE J. Engrg. Mechanics Div., 107 (EM5), pp 907-915 (Oct 1981) 4 figs, 6 refs

**Key Words:** Active control, Active vibration control, Modal control technique

A structure with active control possesses a mechanism to apply forces on the structure by prestressing cables or other

suitable devices to reduce the structure response. This mechanism is controlled by current or voltage produced by sensors located at various points of the structure, and this current or voltage is related to the response of the structure at the sensor location. The modal approach is a technique for designing this mechanism. When using the modal technique, the effect of the active control mechanism on the structure response can be presented by the so-called influence matrix. This matrix indicates the effect of the active control mechanism on the different modes of the structure.

82-348

**Optimum Tuning and Damping of a Dynamic Vibration Absorber Applied to a Force Excited and Damped Primary System**

A.G. Thompson

Dept. of Mech. Engrg., The Univ. of Adelaide, South Australia, J. Sound Vib., 77 (3), pp 403-415 (Aug 8, 1981) 8 figs, 11 refs

**Key Words:** Dynamic vibration absorption (equipment), Tuning, Spring constants, Damping coefficients

The frequency locus method is summarized and then applied to the optimization of the spring and damper rates for a dynamic vibration absorber. The primary system to which the vibration absorber is attached consists of a force-excited sprung mass with associated viscous damping. The construction of the frequency loci for the overall system leads to the determination of graphical criteria for the optimization, and thence to the discovery of a tuning function which enables the optimal natural frequency for the absorber to be determined.

82-349

**Guideway-Suspension Tradeoffs in Rail Vehicle Systems**

R.C. White, Jr. and N.K. Cooperrider

Elect. and Computer Engrg., Arizona State Univ., Tempe, AZ, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 237-244 (Sept 1981) 11 figs, 3 tables, 24 refs

**Key Words:** Railroad trains, Suspension systems (vehicles)

This study addresses the question of whether rail passenger vehicles with more sophisticated (and more expensive) suspensions can operate on rougher (and less expensive) track with an overall lower net cost for the guideway-vehicle system. Four suspensions, representing a range of performance

and cost, are optimized for operation on the roughest possible track. Two of the advanced guideway-vehicle systems appear to result in an overall cost savings. However, because of uncertainties in the estimates of guideway maintenance cost, these conclusions are regarded as illustrative of our methodology rather than quantitatively reliable.

#### 82-350

##### **Optimum Vehicle Suspensions Minimizing RMS Rattlespace, Sprung-Mass Acceleration and Jerk**

D. Hrovat and M. Hubbard

Scientific Res. Lab., Ford Motor Co., Dearborn, MI, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 228-236 (Sept 1981) 9 figs, 1 table, 26 refs

**Key Words:** Suspension systems (vehicles), Single degree of freedom systems, Optimization

The optimal suspension structure for a simple one-degree-of-freedom vehicle model is derived using Linear-Quadratic regulator theory. In addition to rms rattlespace and acceleration, rms jerk is included in the performance index. The suspension structure contains a skyhook spring as well as the more well known skyhook damper to inertial ground and must be mechanized actively except for the shock isolation problem with no ground motion. Charts are presented which enable preliminary design calculations to be done graphically. Using frequency response and time response techniques, performance is compared to that of optimal suspensions disregarding jerk.

#### 82-351

##### **Suspension System Synthesis for Mass Transport Vehicles with Prescribed Dynamical Behavior**

J. Angeles and I. Espinosa

Nat. Autonomous Univ. of Mexico, Mexico, ASME Paper No. 81-DET-44

**Key Words:** Suspension systems (vehicles), Mass transportation

A synthesis procedure to produce redesign recommendations for the suspension of mass transport cars is presented. The objective of the study is to improve the performance of the suspension system under dynamic conditions, so as to yield resonant velocities outside the range of most frequent operation.

## **SPRINGS**

(Also see No. 414)

#### 82-352

##### **Base-Plate Effects on Pipe-Support Stiffness**

B.V. Winkel and F.R. LaSalle

Hanford Engrg. Development Lab., Richland, WA, Rept. No. CONF-810625-7, 11 pp (Jan 14, 1981) (Presented at ASME PVP conference, Denver, CO, June 21, 1981)

HEDL-SA-2276-FP

**Key Words:** Springs (elastic), Supports, Piping systems, Seismic design, Nuclear power plants, Power plants (facilities)

Present nuclear power plant design methods require that support spring rates be considered in the seismic design of piping systems. Base plate flexibility can have a significant effect on the spring rates of these support structures. This paper describes the field inspection, test, and analytical techniques used to identify and correct excessively flexible base plates on the Fast Flux Test Facility pipe support structures.

#### 82-353

##### **Seismic Design of Deadweight Supports**

S.E. Wagner and M.J. Anderson

Hanford Engrg. Development Lab., Richland, WA, Rept. No. CONF-810625-8, 6 pp (Mar 1981) (Presented at ASME PVP conference, Denver, CO, June 21, 1981)

HEDL-SA-2280

**Key Words:** Springs (elastic), Supports, Piping systems, Seismic design

Constant and variable spring supports are used to support the deadweight of piping systems. They are not designed to support pipe seismic loads. They are, however, subject to the base structure accelerations during a seismic event and must continue to support the pipe after the event. This paper discusses the analytical and test techniques used to seismically qualify deadweight supports for the liquid sodium piping on the Fast Flux Test Facility.

## **TIRES AND WHEELS**

#### 82-354

##### **Lorry Tyre Noise**

M.C.P. Underwood

Transport and Road Res. Lab., Crowthorne, UK,  
Rept. No. TRRL-LR-974, 50 pp (1981)  
PB81-228215

**Key Words:** Tires, Noise generation, Interaction: tire-pave-  
ment

This report examines the noise produced by the action of lorry tires rolling on road surfaces and attempts to identify both the main sources and the mechanism of noise generation. A parametric study showed the rolling speed of the tire was the main factor affecting the overall levels of tire noise. Other factors of importance were wheel loads, tire tread and road surface pattern, tire construction and materials, acoustic absorption by the road surface and the presence of surface water. The study of sources established tire surface vibration as the main source of tire noise and other sources including 'air pumping' and aerodynamic noise were not found to contribute significantly to the overall levels on conventional road surfaces.

**82-355**

**An Experimental and Analytical Investigation of the Vibration Noise Generation Mechanism in Truck Tires**

A.C. Eberhardt

Dept. of Mechanical and Aerospace Engrg., North Carolina State Univ. at Raleigh, Rept. No. DOT-HS-805 868, 159 pp (Mar 1981)  
PB81-205593

**Key Words:** Tires, Truck tires, Noise generation, Vibration excitation

The mechanism of sound radiation by vibration of a tire surface is investigated. The effects on sound radiation of acoustically slow structural waves, boundary conditions, and structural damping are reviewed. Simple vibration sound models are shown inadequate to predict the experimentally measured sound field. A correlation between tire vibration and sound is demonstrated by experiments that relate tire surface vibration levels to levels of near-field and far-field sound. Further evidence of correlation is shown by the coherence function computed between experimentally measured tire vibration and sound. Experimental procedures and data analysis techniques are described in an appendix.

**82-356**

**Influence of Wheel/Rail Contact Geometry on Large Amplitude Wheelset Equations of Motion**

T.D. Burton

Dept. of Mech. Engrg., Washington State Univ., Pullman, WA, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 211-218 (Sept 1981)  
2 figs, 20 refs

**Key Words:** Wheelsets, Interaction: rail-wheel

The nonlinear equations of motion and velocities of creep of a simply restrained wheelset on tangent track are derived for the case of large amplitude motion including flange contact. The nonlinearities considered are those arising from the wheel/rail contact geometry. It is shown that during flange contact the lateral creep velocity may differ by as much as 30-40 percent when compared to that calculated using the usual creep velocity models.

**BLADES**

(Also see Nos. 288, 524, 543, 544)

**82-357**

**Dynamic Response of Blades and Vanes to Wakes in Axial Turbomachinery**

R.N. Tadros and M. Botman

Pratt & Whitney Aircraft of Canada Ltd., Longueuil, Quebec, Canada, ASME Paper No. 81-DET-33

**Key Words:** Blades, Turbomachinery blades, Vanes, Aerodynamic loads

A basic method of analysis has been developed which allows the prediction of vibratory stresses in blades and vanes of axial turbomachinery due to the aerodynamic interaction with upstream and downstream stages, and in particular due to the wakes. In its present limited form the program has predicted results with reasonable accuracy. Further work is in progress to remove some of the limitations.

**82-358**

**Experimental Investigation of Flutter in Midstage Compressor Designs**

R.R. Jutras, M.J. Stallone, and H.R. Bankhead  
General Electric Co., Evendale, OH, J. Aircraft, 18 (10), pp 874-880 (Oct 1981) 9 figs, 3 tables, 3 refs

**Key Words:** Flutter, Compressors, Rotor blades (turbomachinery), Blades, Airfoils, Experimental test data

A comprehensive flutter test program was performed at subsonic/transonic Mach numbers in a nonrotating Annular

Cascade rig. This rig was designed to investigate negative incidence choke flutter and positive incidence stall flutter. The objective of the program reported here was to establish choke flutter criteria for use in design of axial flow gas turbine airfoils which operate in the subsonic/transonic aerodynamic environment.

## BEARINGS

(Also see Nos. 257, 303)

82-359

### Specific Film Thickness - A Closer Examination of the Effects of EHL Film Thickness and Surface Roughness on Bearing Fatigue

C.N. Rowe

Mobil Res. and Dev. Corp., Princeton, NJ, ASLE Trans., 24 (4), pp 423-420 (Oct 1981) 5 figs, 4 tables, 15 refs

**Key Words:** Bearings, Fatigue life, Surface roughness, Lubrication

Analysis of literature bearing fatigue life results shows that fatigue life is not a simple function of the widely accepted specific film thickness which is the ratio of the EHL film thickness to composite surface roughness. Instead, the influence of film thickness on bearing life increases with increasing surface roughness; at about 0.20 micrometer (8 microinch) composite roughness life increases with the square root of  $h$  while at about 0.46 micrometer (18 micro-inches) life increases with  $h$  squared. The negative effect of surface roughness on bearing life appears to be relatively independent of film thickness.

82-360

### The Dynamic Behaviour of Squeeze Films in One-Dimensional Porous Journal Bearings Lubricated by a Micropolar Fluid

Kh. Zaheeruddin

Dept. of Mech. Engrg., Aligarh Muslim Univ., Aligarh 202001, India, Wear, 71 (2), pp 139-152 (Sept 8, 1981) 7 figs, 7 refs

**Key Words:** Bearings, Journal bearings, Squeeze film bearings, Porous materials, Lubrication

The generalized Reynolds equation governing the pressure distribution for a micropolar lubricant in a dynamically

loaded porous journal bearing is derived and applied to one-dimensional squeeze film journal bearings operating under a cyclic load. The analysis indicates how the microstructure in the lubricant, the permeability of the bearing material and the bearing wall thickness influence the operating eccentricity ratio.

82-361

### Bearing-System Dynamic with General Misalignment in the Journal Bearings

T.A. Pafelias and C.A. Broniarek

Rensselaer Polytechnic Inst., Troy, NY, ASLE Trans., 24 (3), pp 379-386 (July 1981) 12 figs, 2 tables, 7 refs

**Key Words:** Bearings, Journal bearings, Alignment, Spring constants, Damping coefficients

Reynolds' equation for a partial journal bearing with both translational and tilting motions has been solved by means of the finite-difference technique. A set of sixteen spring and sixteen damping coefficients is used to develop a "point matrix" for a bearing of finite dimensions with misalignment, in a form compatible with the existing transfer matrix methods. The calculation procedure is programmed in FORTRAN IV. It was found that misalignment has an effect on the spring and damping coefficients at a low Sommerfeld number (i.e., high load of the bearing).

82-362

### The Cross-Coupling Dynamic Coefficients of Tilting-Pad Bearings

M. Malik and R. Sinhasan

Dept. of Mech. and Indus. Engrg., Univ. of Roorkee, Roorkee 247672, India, Wear, 71 (1), pp 103-105 (Sept 1, 1981) 1 fig, 2 refs

**Key Words:** Bearings, Tilting pad bearings, Stiffness coefficients, Damping coefficients

There is some misconceptions in the literature concerning the cross-coupling stiffness and damping coefficients of tilting-pad bearings; these have been reported as equal to zero. Analytical expressions of the dynamic coefficients of the bearing in terms of the dynamic coefficients of the individual pads have been derived to show that the cross-coupling coefficients of the bearing cannot in general be zero.

82-363

**A New Approach to the Theoretical Calculation of the Dynamic Coefficients of Tilting-Pad Bearings**

F. Martelli and G. Manfrida

Istituto di Energetica, Facoltà di Ingegneria, Università Degli Studi di Firenze, Via di S. Marta 3, 50139, Florence, Italy, *Wear*, **70** (2), pp 249-258 (Aug 1, 1981) 3 figs, 9 refs

**Key Words:** Bearings, Tilting-pad bearings, Stiffness coefficients, Damping coefficients

A new method, called the "force assembly method," for the numerical calculation of the dynamic coefficients of tilting-pad bearings is proposed. The method is based on a finite element solution of the pressure distribution on the surface and the eight coefficients are determined directly by considering the bearing as a whole; they are not determined from the traditional assembly of modified fixed-pad data. Some important advantages in theoretical consistency are found without any increase in computational difficulty.

82-364

**Optimum Bearing-Support Damping for Rotor-Bearing Systems for Maximum Stable Operating Speed Range**

P.S. Chari, C.P. Reddy, and G.M. Reddy

Bharat Heavy Electricals Ltd., India, ASME Paper No. 81-DET-69

**Key Words:** Damping, Supports, Bearings Rotors

For a typical rotor-bearing system, stability maps are presented for different values of dimensionless bearing-support damping. The optimum bearing-support damping which ensures the greatest stable operating speed range for the rotor-bearing system is determined.

## BELTS

82-365

**Vibration Measurement of a Moving Tangential Drive Belt**

R.S. Smith III and P.D. Emerson

North Carolina State Univ., Raleigh, NC, ASME Paper No. 81-DET-36

**Key Words:** Mechanical drives, Belt drives, Vibration measurement, Spindles

Vibration of moving tangential drive belts in textile machinery was studied by coating the belts with electrically conductive paint and monitoring belt motion with a capacitive transducer. Spectral analyses of tape recordings of the capacitive transducer output were utilized to determine dependence of the first two natural frequencies of a spindle-to-spindle belt span speed, tension, and span length.

## GEARS

82-366

**A Method of Selecting Grid Size to Account for Hertz Deformation in Finite Element Analysis of Spur Gears**

J.J. Coy and C.H.C. Chao

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82623, E-728, 27 pp (1981)  
N81-27525

**Key Words:** Gear teeth, Finite element technique, Cylinders, Noise reduction

A method of selecting grid size for the finite element analysis of gear tooth deflection is presented. The method is based on a finite element study of two cylinders in line contact, where the criterion for establishing element size was that there be agreement with the classical Hertzian solution for deflection. The results are applied to calculate deflection for the gear specimen used in the NASA spur gear test rig. Comparisons are made between the present results and the results of two other methods of calculation. The results have application in design of gear tooth profile modifications to reduce noise and dynamic loads.

## COUPLINGS

82-367

**Finding the Right Flexible Coupling**

D. McCormick

Design Engineering, Berkshire Common, Pittsfield, MA 02101, *Des. Engrg.*, **52** (10), pp 61-63, 65, 66 (Oct 1981)

**Key Words:** Couplings, Flexible couplings

The data required for the selection of a flexible coupling are the spring rate, the torque requirement, and misalignment

capacity. Calculation required for these data are presented and their use in the selection of the right coupling from the manufacturers catalogues is described.

## FASTENERS

(Also see Nos. 389, 390)

82-368

### Fatigue of Welded Steel Structures due to Strong Earthquakes -- Strain Controlled Low-Cycle Fatigue Tests of Cylindrical Specimens

K. Kaneta and I. Kohzu

Dept. of Architectural Engrg., Kyoto Univ., Kyoto, Japan, *Memoirs of the Faculty of Engrg., Kyoto Univ.*, XLIII (1), pp 102-123 (Jan 1981) 8 figs, 6 tables, 28 refs

**Key Words:** Joints (junctions), Welded joints, Steel, Fatigue life, Earthquake response, Seismic response

This experiment was carried out in order to examine cyclic inelastic actions and low-cycle fatigue properties of butt welded joints of steel structures. Base metals which consisted of mild to high tensile strength steel, namely, SS41 to HT80, were used. The welded joints were made by means of various kinds of butt welding processes. These base metals and the welded joints were fabricated and shaped into cylindrical specimens, and loaded cyclically by a uniaxial tension-compression method, to the point where the specimens were fractured. No significant differences between the base metal and the welded joint were observed with respect to the cyclic stress-strain relationships and the energy absorption capacities at the steady-state in non-dimensional forms.

## VALVES

82-369

### Dynamic Evaluation of a Nuclear Main Steam Isolation Valve Actuator

A.J. Patten

Gulf & Western Mfg., Warwick, RI, ASME Paper No. 81-DET-32

**Key Words:** Valve actuators, Nuclear reactor components, Seismic design

One of the major objectives of this paper is to alert both designer-suppliers and specification writers that the subject

of seismic testing, particularly the requirements of natural frequency, is not being addressed in a concise workable manner that is needed to expeditiously complete contracts. The terminology of "natural frequency" is too general for complex valve actuators.

## SEALS

82-370

### Dynamic Analysis of Wedge-Type Shaft Seal

S.K. Dhagat, R. Sinhasan, and D.V. Singh

Government Engrg. College, Jabalpur 482011, India, *ASLE Trans.*, 24 (3), pp 387-397 (July 1981) 14 figs, 2 tables, 11 refs

**Key Words:** Seals, Shafts, Wedges, Stiffness coefficients, Damping coefficients

The hydrodynamic seal under study here consists of two lands -- one plain and the other having a wedge. The two lands are separated by a circumferential oil-supply groove. The wedge parameters significantly affect the performance of seal. The effects of various wedge parameters on dynamic stability of the hydrodynamic seal have been studied. *Stiffness and damping coefficients for lateral and skew motions*, critical nondimensional mass and critical nondimensional inertia have been evaluated for different wedge parameters at different eccentricities. The equations of motion of the seal center for four degrees of freedom have been derived and considering lateral and skew motions, stability studies have been made using Routh criteria.

82-371

### Dynamic Tracking of Angular Misalignment in Liquid-Lubricated End-Face Seals

R. Metcalfe

Atomic Energy of Canada, Ltd., Chalk River, Ontario K0J 1J0 Canada, *ASLE Trans.*, 24 (4), pp 509-516 (Oct 1981) 9 figs, 15 refs

**Key Words:** Seals, Alignment

End-face seals sometimes fail because the flexibly mounted face is unable to track the inevitable angular misalignment (relative to the shaft axis) of the fixed face, resulting in rubbing contact. It is important, then, that the critical amount of misalignment just to cause contact in a fully liquid-lubricated seal should be known so allowances can be made in the manufacturing and assembly tolerances. An

analysis of dynamic tracking is presented for both common end-face seal arrangements. Expressions for critical misalignment are derived in terms of inertia, elastomer stiffness and damping, and fluid-film hydrostatic and hydrodynamic moment effects in the diametral tilt mode. Fluid-film effects are found to promote tracking, elastomer effects to resist. Tilt inertia resists tracking only for the flexibly mounted stator arrangement. However, as the inertia term is generally insignificant, this arrangement is preferred because, in practice, it is much easier to achieve good alignment of a rotating face fixed to the shaft than a stationary face fixed in a housing.

## STRUCTURAL COMPONENTS

### STRINGS AND ROPES

(Also see No. 291)

82-372

#### Spring Safety Retainer

J.E. Hibbs, G.W. Chalmers, B.C. Bartels, J.O. Eaton, and E.W. Lauer

Dept. of the Navy, Washington, DC, 7 pp (Mar 30, 1981)

PAT-APPL-6-249 574

**Key Words:** Springs, Shafts (machine elements), Safety devices

A spring is tightly wrapped about a circumference of a shaft and a spring safety retainer engages a periphery of the torsional spring about the shaft thereby securing the spring to the shaft. One end of the spring safety retainer engages the inner involutational surface of the torsion spring. The shaft can be rotated by various means such as a solenoid, vibration and/or shock. One object of this invention is a spring safety retainer able to securely hold a spring to a shaft under rigorous conditions. Another object is a spring safety retainer less costly to manufacture than previous retainers.

### CABLES

82-373

#### Transmission Line Dynamic/Static Structural Testing

L. Kempner, Jr., R.C. Stroud, and S. Smith

Bonneville Power Administration, Portland, OR 97208, ASCE J. Struc. Div., 107 (ST10), pp 1906 (Oct 1981) 7 figs, 7 tables, 6 refs

**Key Words:** Transmission lines, Dynamic tests, Towers, Finite element technique

During 1978, full-scale structural-dynamic and static tests were performed on a 1,200-kV mechanical-test line. The objectives of the test program were to: characterize the dynamic and static properties of the 1,200-kV eight-conductor bundle and one of the suspension towers; improve/verify dynamic finite element techniques used for transmission tower modeling; and investigate and develop experimental testing and analytical methods for applying structural-dynamic technology to transmission-line systems. This paper presents the most significant results of the test program.

82-374

#### Dynamics of Undersea Cables

J.M. Syck

Naval Underwater Systems Ctr., New London Lab., New London, CT, Rept. No. NUSC-TR-6313, 111 pp (May 17, 1981)

AD-A099 781

**Key Words:** Cables (ropes), Underwater structures, Submerged structures

Mathematical models have been used for some time to predict the deformation of undersea cables due to ocean currents; however, there have been very few measurements made that permit verification of model results against observations of cable deformation. A dynamic model and a static model have been used to make calculations of shape for an experimental acoustic array deploy in the North Atlantic Ocean. The calculations were then compared to careful measurement of the shape of the array, which was a cable 6 km long suspended several kilometers above the sea floor. Both models are in qualitative agreement with observation, but they underestimate the magnitude of the maximum deformation by a factor of about 2.

### BARS AND RODS

(Also see No. 470)

82-375

#### Anchorage Characteristics for Reinforcing Bars Subjected to Reversed Cyclic Loading

I.-J. Lin

Ph.D. Thesis, Univ. of Washington, 345 pp (1981)  
UM 8121217

**Key Words:** Reinforced concrete, Bars, Earthquake response

An analytical model is developed that predicts the load-slip characteristics of reinforcing bars anchored within exterior beam-column joints in reinforced concrete structures subject to earthquake loading. The analytical results predicted by the model are compared to experimental results for 22 specimens. Variables included in the specimens were the loading history for the bar, the yield strength for the bar, the size of the bar, the embedment length for the bar, the strength of the concrete and the use of a straight bar or a bar terminating with a standard 90 degree hook. Good agreement is obtained between the measured results and those predicted by the model for both monotonic and reversed cyclic loading.

**82-376**

**Dynamic Interaction of an Embedded Cylindrical Rod under Axial Harmonic Forces**

R. Parnes and P. Weidlinger

Dept. of Solid Mechanics, Materials and Structures,  
School of Engrg., Tel-Aviv Univ., 69978 Ramat-Aviv,  
Israel, Intl. J. Solids Struct., 17 (9), pp 903-913  
(1981) 6 figs, 8 refs

**Key Words:** Rods, Interaction: soil-structure, Pipes (tubes),  
Seismic response

A model representing a pipe buried in soil is studied in order to determine the dynamic response of such a system. The model considered is represented by an embedded cylindrical rod subjected to time-harmonic longitudinal forces acting periodically at intervals in alternating directions. (Such a loading pattern corresponds to the incoherent component of earthquake excitation.) The degree of interaction between the rod and surrounding medium as well as the amount of damping is established. The rod and medium are assumed to behave as linear isotropic elastic materials and the interaction between the medium and rod is assumed to occur through a shear force mechanism acting at the interface. The response is found to be expressible in terms of non-dimensional ratios of density, velocity of wave propagation and an aspect ratio. Results are presented in terms of dynamic amplification factors for various frequencies of the applied forces. Peak response and resonant frequencies are determined and regions where radiation damping occurs are established. A physical interpretation of the results is given.

**82-377**

**Response of an Elastically Embedded Rod Subjected to Periodically Spaced Longitudinal Forces**

R. Parnes

Dept. of Solid Mech., Materials and Structures,  
School of Engrg., Tel-Aviv Univ., 69978 Ramat-Aviv,  
Israel, Intl. J. Solids Struct., 17 (9), pp 891-901  
(1981) 13 figs

**Key Words:** Rods, Interaction: soil-structure, Pipes (tubes),  
Seismic response

The dynamic response of buried pipelines to earthquakes is best expressed in terms of dynamic amplification factors, i.e. as the ratio of dynamic to static response. In the present paper, the system is represented by a model consisting of a cylindrical rod of radius embedded in an elastic medium. The required interacting static response of rods subjected to periodic longitudinal forces at intervals and acting in alternate directions, is obtained. Such a load pattern corresponds to the incoherent motion occurring in earthquakes. The static displacements and interacting stresses of the system are established and are found to be dependent, for a given medium, on the ratio of stiffness of the medium and rod as well as on the aspect ratio. Numerical results are presented for a series of rods governed by the above non-dimensional parameters.

## BEAMS

**82-378**

**An Evaluation Technique for Vibration Modes of Structures Interacting with Soil**

G. Solari and D. Stura

Istituto di Scienza delle Costruzioni, Facoltà di  
Ingegneria, Via Montallegro 1, 16145 Genova, Italy,  
Engrg. Struct., 3 (4), pp 225-232 (Oct 1981) 7 figs,  
2 tables, 16 refs

**Key Words:** Beams, Cantilever beams, Interaction: soil-structure,  
Natural frequencies, Mode shapes

In this paper the natural frequencies and modal shapes of a structure interacting with soil and modeled as a cantilever non-prismatic beam on which concentrated masses are applied have been evaluated through the application of the Rayleigh-Ritz method. On the basis of this general formulation a numerical program was developed; subsequently some simple expressions allowing a good evaluation of the fundamental frequency were derived. In conclusion some numerical examples are also presented in order to illustrate the reliability of the proposed methodology.

**82-379**

**Ensemble Averages of Power Flow in Randomly Excited Coupled Beams**

H.G. Davies and M.A. Wahab

Dept. of Mech. Engrg., Univ. of New Brunswick, Fredericton, New Brunswick, Canada, E3B 5A3, *J. Sound Vib.*, 77 (3), pp 311-321 (Aug 8, 1981) 6 figs, 14 refs

**Key Words:** Beams, Random excitation, Statistical energy methods

The transmission of transverse vibrational energy between two coupled beams subjected to random excitation is considered. Extensive numerical results are given for the frequency decomposition of power flow between the beams. The power flow is a function of the three non-dimensional parameters describing frequency, length ratio, and damping or modal overlap ratio. Single frequency and octave band averages are shown for various values of length ratio and means and variances are calculated for the ensemble of systems corresponding to a uniform distribution of length ratio greater than one and less than two. Various approximate results based on modal analysis and on SEA are compared with the exact results.

**82-380**

**Maximum Displacement of Continuous Systems Excited by Incompletely Described Loads**

N. Popplewell, D.A. Scarth, W.J. McAllister, and N.A.N. Youssef

Dept. of Mech. Engrg., Univ. of Manitoba, Winnipeg, Canada R3T 2N2, *J. Sound Vib.*, 77 (3), pp 387-395 (Aug 8, 1981) 1 fig, 10 refs

**Key Words:** Continuous systems, Beams, Flexural vibration

Two previously established methods of predicting the largest displacement modulus of discretized structures under incompletely described loads are extended logically to continuous structures. The general procedure is illustrated by using the particular example of a simply supported, homogeneous beam whose free flexural vibrations can be characterized very easily. Predictions based upon point loaded beams suggest that the accuracy of both methods deteriorates as the effective number of participating modes increases. Efforts for improvement should concentrate generally upon upgrading knowledge of the duration and then the energy of the forces producing the dominant modes.

**82-381**

**Dynamics of an Axially Moving Beam Submerged in a Fluid**

I.A. Taleb and A.K. Misra

McGill Univ., Montreal, Quebec, Canada, *J. Hydro-nautics*, 15 (1-4), pp 62-66 (Dec 1981) 5 figs, 2 tables, 10 refs

**Key Words:** Beams, Submerged structures, Flexural vibration

The dynamics of an axially moving slender beam having a uniform circular cross section and immersed in an incompressible fluid is analyzed. The equation for small transverse vibrations is obtained, taking into account the inviscid and viscous fluid dynamic forces. The transverse displacement is expanded in terms of a set of time-dependent admissible functions to yield a set of nonautonomous ordinary differential equations. Uniform and exponential extension of the beam are considered, and the truncated set of equations is integrated numerically. The system parameters are varied for the two procedures and their influence on stability is noted.

**82-382**

**Damping of Vibrations in Continuous Mechanical Systems**

R. Lunden

Ph.D. Thesis, Chalmers Univ. of Tech., Div. of Solid Mechanics, Goteborg, Sweden, 161 pp (1981)

**Key Words:** Beams, Vibration damping, Finite element technique

Vibrating mechanical beam systems with distributed mass, stiffness, and damping are studied. Numerical models are developed. Computed results are verified by experiments. Distributions of additive damping are optimized. One application is to a lightweight skeletal machine foundation.

**82-383**

**Gravity and Dynamic Response of Vertical Beams**

B.D. Westermo

Dept. of Civil Engrg., San Diego State Univ., San Diego, CA, *ASCE J. Engrg. Mechanics Div.*, 107 (EM5), pp 917-934 (Oct 1981) 14 figs, 9 refs

**Key Words:** Beams, Gravity effects, Resonant frequencies

The influence of the gravity forces upon the steady state and transient dynamic response of vertical beams is examined. Both the shear and Euler-Bernoulli (moment) type of beam models are reformulated with the gravity load included. The calculated response of such models show that the gravity effect lowers the resonant frequencies of the system. For

transient excitations with predominant frequencies less than the fundamental frequency of the beam, the frequency response of a beam including gravity can be approximated from the nongravity response curve.

**82-384**

**An Improved Model for Soil-Structure Interaction Analysis**

A.Q. Mohammad

Ph.D. Thesis, Polytechnic Inst. of New York, 170 pp (1981)

UM 8118889

**Key Words:** Interaction: soil-structure, Beams, Winkler foundations, Half-space

The common design practice of engineering analysis of beams supported on soil foundations is to follow a simplified approach wherein the contact pressure is conveniently assumed to vary linearly along the length of the beam. Numerical results indicate that displacements, pressure distribution, and bending moment differ considerably as compared to Winkler solution.

## CYLINDERS

**82-385**

**Influence of Initial Geometrical Imperfections on Vibrations of Axially Compressed Stiffened Cylindrical Shells**

J. Singer and J. Prucz

Dept. of Aeronautical Engrg., Technion - Israel Inst. of Tech., Haifa, Israel, Rept. No. TAE-369, 114 pp (Feb 1980)

N81-27553

**Key Words:** Shells, Cylindrical shells, Stiffened shells, Geometrical imperfection effects

The vibrations of stiffened cylindrical shells having axisymmetric or asymmetric initial geometrical imperfections and axial preload are studied. The results show that stiffening of the shell will lower the imperfection-sensitivity of its free vibrations, but the decrease depends on the type of stiffening (stringer or rings), the mode shapes of the vibration and the imperfection, the stiffener strength and eccentricity. The imperfection-sensitivity decrease, caused by the stiffeners, is greater for vibration mode shapes with high imperfection-sensitivity than for other vibration mode shapes.

**82-386**

**Mathematical Model, Instability Mechanisms, and Stability Criteria of a Group of Circular Cylinders Subjected to Crossflow**

S.S. Chen

Argonne Natl. Lab., Argonne, IL, Rept. No. ANL-CT-81-22, 64 pp (May 1981)

DE81024487

**Key Words:** Cylinders, Circular cylinders, Fluid-induced excitation, Flutter

A mathematical model is presented for a group of circular cylinders subject to crossflow. The fluid-force coefficients in the model are determined from available experimental data. It is found that there are three dynamic instability mechanisms: galloping controlled by fluid damping, flutter controlled by fluidelastic force, and coupled galloping-flutter instability controlled by both fluid damping and fluidelastic force. Closed-form solutions of the critical flow velocity for galloping and flutter are obtained based on constrained modes. Experimental data are found to be in good agreement with the analytical results.

**82-387**

**The Response and the Lift Force Analysis of a Cylinder Oscillating in Still Water**

Y.-s. Park

Ph.D. Thesis, Iowa State Univ., 131 pp (1981)

UM 8122553

**Key Words:** Cylinders, Elastic foundations, Submerged structures, Underwater structures, Fluid-induced excitation

An experimental study was made about an elastically mounted cylinder exposed to a periodic fluid flow field. The corresponding analysis placed emphasis on the prediction of fluid lift forces and cylinder responses normal to the deterministic, sinusoidal oscillating flow. A cylinder model was driven sinusoidally in still fluid in order to give a relative sinusoidal motion between the fluid and cylinder. This experimental arrangement was selected due to both a simple implementation of experimental apparatus and a strict control of the input variables such as cylinder driving amplitude and frequency.

## FRAMES AND ARCHES

**82-388**

**Dynamic Safety Analysis**

H.S. Norville

Ph.D. Thesis, Purdue Univ., 117 pp (1981)  
UM 8123685

**Key Words:** Framed structures, Base excitation, Random excitation

In this thesis, a method is developed to compute first-passage probabilities for linear elastic structures subjected to random base accelerations. The base accelerations consist of both horizontal and vertical components. Specifically, the effect of the vertical accelerations on the first passage probabilities are investigated herein.

## PANELS

(See Nos. 398, 542)

## PLATES

82-389

### **Sound Transmission and Mode Coupling at Junctions of Thin Plates, Part I: Representation of the Problem**

P.G. Craven and B.M. Gibbs

Computer Lab., Univ. of Liverpool, Liverpool L69 3BX, UK, J. Sound Vib., 77 (3), pp 417-427 (Aug 1981) 5 figs, 18 refs

**Key Words:** Plates, Joints (junctions), Sound transmission

A description is given of a versatile method of analysis of sound waves generated at a junction of plates as a result of a wave incident on any one of the plates. Thin plate theory is used in calculating mode coupling and energy intensity and the description is generalized in that the junction can be of two to four plates, the incident wave can have any mode of vibration, and dissipative loss factors can be included in the calculation. Results are compared with those of previous workers for the case of a bending wave incident at a cross junction and at a corner and the description is extended to include in-plane vibration incident at the same junctions.

82-390

### **Sound Transmission and Mode Coupling at Junctions of Thin Plates, Part II: Parametric Survey**

B.M. Gibbs and P.G. Craven

Dept. of Building Engrg., Univ. of Liverpool, Liver-

pool L69 3BX, UK, J. Sound Vib., 77 (3), pp 429-435 (Aug 8, 1981) 5 figs, 4 refs

**Key Words:** Plates, Joints (junctions), Sound transmission

In the second part of this discussion of sound transmission at the junction of structural plates results are presented of a parametric survey conducted on the performance of a T-junction of concrete plates of various thickness, density, bending rigidity and loss factor. It is seen that alteration of bending rigidity and density produces greater variation in transmission loss than that of plate thickness or material loss factor. Indeed an increase in loss factor can lead to a detrimental increase in mode coupling between travelling bending waves and in-plane waves at all angles of incidence. In general in-plane vibration suffers less reduction in level at low frequencies at junctions of dissimilar plates than does bending vibration.

82-391

### **Transverse Vibrations and Elastic Stability of Circular Plates of Variable Thickness and with Non-Uniform Boundary Conditions**

P.A.A. Laura and G.M. Ficcadenti

Inst. of Applied Mech., Puerto Belgrano Naval Base, 8111 Argentina, J. Sound Vib., 77 (3), pp 303-310 (Aug 8, 1981) 1 fig, 8 tables, 5 refs

**Key Words:** Plates, Circular plates, Flexural vibration, Variable cross section

An approximate method is presented for dealing with transverse vibrations of circular plates of variable thickness in the case of supports having rotational flexibility which varies in an arbitrary manner around the boundary. It is also assumed that the plate is subjected to a hydrostatic state of in-plane stress; accordingly the buckling coefficient is obtained by setting the frequency coefficient equal to zero in the frequency determinant. A unified yet simple and straightforward approach has been developed in order to solve this rather difficult elastomechanics problem.

82-392

### **Application of a Series-Type Method to Vibration of Orthotropic Rectangular Plates with Mixed Boundary Conditions**

Y. Narita

Computer Center, Hokkaido Inst. of Tech., Sapporo 061-24, Japan, J. Sound Vib., 77 (3) pp 345-355 (Aug 8, 1981) 5 figs, 3 tables, 22 refs

**Key Words:** Plates, Rectangular plates, Orthotropism, Boundary condition effects, Natural frequencies, Mode shapes

The object of this paper is to show an application of a series-type method to the free vibration of an orthotropic rectangular plate with mixed boundary conditions. The rectangular plate considered is elastically constrained or clamped along a few parts of its edge and simply supported on the remainder. A frequency equation is derived to accommodate rectangular orthotropy of the plate by the extension of a previously developed method, and subsequent algebraic manipulation leads to the improved equation, yielding natural frequencies of the plate with very good accuracy. The method is demonstrated for numerical examples where one, two or three parts are constrained along the boundary of the square plate, and the effects of varying constraint and orthotropic parameters on the natural frequencies and mode shapes are studied.

#### 82-393

##### **The Normal Force on a Planing Surface**

P.R. Payne

Payne, Inc., Annapolis, MD, J. Hydronautics, 15 (1-4), pp 39-47 (Dec 1981) 17 figs, 44 refs

**Key Words:** Plates, Hydrofoil craft

The steady-state dynamic normal force acting on a planing plate is calculated from the downward velocity imparted to the virtual hydrodynamic mass associated with the plate's cross section. This virtual mass can, in principle, be evaluated for any plate cross section, although we currently have available values for only a limited range of shapes. The present paper constitutes a refinement of the analysis and, for the first time, a detailed comparison of its predictions with experimental data for steady-state planing.

#### 82-394

##### **Sliding Regimes and Anisotropy in Optimal Design of Vibrating Axisymmetric Plates**

N. Olhoff, K.A. Lurie, A.V. Cherkasov, and A.V. Fedorov

Dept. of Solid Mech., The Technical Univ. of Denmark, Lyngby, Denmark, Intl. J. Solids Struct., 17 (10), pp 931-948 (1981) 4 figs, 23 refs

**Key Words:** Plates, Flexural vibrations, Fundamental frequency, Optimum design

This paper deals with optimal design of solid, elastic, axisymmetric plates performing free, transverse vibrations. It is the

objective to determine the plate thickness distribution from the condition that the plate volume is minimized for a given value of the fundamental natural frequency, or for a given higher order natural frequency that corresponds to a vibration mode with a prescribed number of nodal diameters. It is found that the Weierstrass necessary condition for optimality is generally not satisfied for a traditional formulation of this problem, and that the optimal design is characterized by a sliding regime of control where the plate thickness exhibits an infinite number of discontinuities, as a system of infinitely thin, circumferential stiffeners are formed on the optimal axisymmetric plate.

#### 82-395

##### **Ultrasonic Sizing of Surface Defects in Plates and Pipes**

M.A.-M.M. Mahmoud

Ph.D. Thesis, Univ. of Waterloo, Canada (1981)

**Key Words:** Plates, Pipes (tubes), Pressure vessels, Fatigue (materials), Crack propagation

Equipment has been built to periodically enlarge saw cuts in plates and pipes at room temperature or 290°C. In the latter case the plates (25.4 mm thick) or thin pipes (12.7 mm thick and 218 mm outside diameter) were part of a pressure vessel operating at 10.4 MPa and 290°C. The defect depth, 1 to 8 mm, was monitored both at room temperature and 290°C using immersion echo amplitude ultrasonic measurements. Attention was focused on sizing defects with transducers positioned on the uncracked side of the specimens.

#### 82-396

##### **Aeroelastic Flutter and Divergence of Graphite/Epoxy Cantilevered Plates with Bending-Torsion Stiffness Coupling**

S.J. Hollowell

Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT-CI-80-67T, 139 pp (Jan 1981) AD-A101 726

**Key Words:** Plates, Cantilever plates, Flutter

The aeroelastic flutter and divergence behavior of rectangular, graphite/epoxy, cantilevered plates with varying amounts of bending-torsion stiffness coupling is investigated for incompressible flow. A general Rayleigh-Ritz formulation is used to calculate flexibility influence coefficients, static deflections, divergence velocities, vibration frequencies, and flutter velocities. Flutter calculations are done using the U-g

method. Test plates were constructed and subjected to static, vibration and wind tunnel tests. Wind tunnel tests indicated static deflections, divergence instabilities, bending-torsion flutter at low angles of attack, and stall flutter at high angles of attack.

**82-397**

**Torsional Oscillations of a Finite Disk**

P.W. Duck

Dept. of Aeronautical and Astronautical Engrg., Ohio State Univ., Columbus, OH, SIAM J. Appl. Math., 41 (2), pp 247-264 (Oct 1981) 7 figs, 12 refs

**Key Words:** Disks (shapes), Torsional vibration

The manner in which the (double) boundary layer formed by a disk performing small amplitude, torsional oscillations reacts and adjusts to three types of discontinuity is studied. The first case considered is that of an infinitely thin disk torsionally oscillating in an infinite fluid. The second example is that of a disk oscillating inside the plane of a fixed flat plate. The final case is when the disk is oscillating inside of the plane of a further, larger disk, also performing torsional oscillations, of a different amplitude and frequency.

## SHELLS

**82-398**

**Vibration of Cylindrical Shells and Panels of Oval Cross-Section**

V.K. Koumoussis

Ph.D. Thesis, Polytechnic Inst. of New York, 285 pp (1980)

UM 811888

**Key Words:** Cylindrical shells, Shells, Panels

This dissertation is divided into two parts. In Part I, the dynamic characteristics of simply supported and infinitely long cylindrical shells of oval cross section are established on the basis of Flugge-type, thin shell theory. In Part II, a method is presented for obtaining the dynamic characteristics of cylindrical panels of non-circular cross section having simply supported, curved edges and any boundary conditions along their straight edges. Moreover, this method is employed in establishing the dynamic characteristics of cylindrical panels of oval cross section, using the Flugge and Donnell-type theories.

**82-399**

**Formulas of Natural Frequency Prediction for Thin Circular Cylinders**

C.B. Sharma

Univ. of Manchester, UK, ASME Paper No. 81-DET-77

**Key Words:** Shells, Cylindrical shells, Natural frequencies

A theoretical investigation of the vibration characteristics of thin circular cylinders based upon the kinematic relations of the first order shell theory of Sanders is given employing a suitable variational technique. Some simplifying approximations in the form of inter-relationships between the displacements are used in two different ways to yield two simple linear frequency relations.

**82-400**

**The Heat Transfer between Concentric Vibrating Circular Cylinders**

E.W. Haddon and N. Riley

School of Computing Studies and Accountancy and School of Math. and Physics, Univ. of East Anglia, Norwich, UK, Quart. J. Mechanics Appl. Math., 34 (3), pp 345-359 (Aug 1981) 8 figs, 12 refs

**Key Words:** Shells, Cylindrical shells, Circular shells, Concentric structures, Harmonic excitation, Heat transfer

In this paper the heat transfer across the annulus between two circular cylinders, which are maintained at different temperatures, when the inner cylinder performs small-amplitude harmonic oscillations perpendicular to its generators and the outer one is at rest is investigated.

**82-401**

**The Response of Ring-Stiffened Elastic Cylindrical Shell of Infinite Length to a Transverse Shock Wave**

Y.-g. Yeh

Inst. of Mech., Academia Sinica, Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, 2, pp 208-221 (1981) 16 figs, 1 table, 11 refs (In Chinese)

**Key Words:** Shells, Cylindrical shells, Stiffened shells, Interaction: structure-fluid, Shock wave propagation

This method employs a simple, unstiffened uniform circular cylindrical shell as a reference structure and treats the ring

stiffeners as external loadings on the uniform shell. Calculation was made for two groups of data and curves were drawn from the calculated results, from which some useful conclusions can be reached. The equations derived in this paper can be reduced to be identical with some equations published by other workers.

#### 82-402

##### **Failure of Liquid Storage Tanks due to Earthquake Excitation**

C.-F. Shih

Ph.D. Thesis, California Inst. of Tech., 199 pp (1981)  
UM 8121417

**Key Words:** Tanks (containers), Storage tanks, Earthquake response, Seismic response, Damage prediction, Interaction: structure-fluid

Above ground liquid storage tanks have suffered serious damage during earthquakes. The damage of tanks can vary from local yielding or buckling of the tank wall, to loss of contents, or to collapse which leads to an unrepairable tank. Considerable work has been carried out on this problem with varying degree of success. However, the results are largely directed toward response rather than failure prediction. The present work consists of scale model testing, correlation with existing analysis and failure prediction with laboratory verification. The scale model testing incorporates dynamic similarity of the fluid/structure interaction problem.

#### 82-403

##### **Seismic Analysis of Submerged Underwater Oil Storage Tanks**

A.H. Helou

Ph.D. Thesis, North Carolina State Univ. at Raleigh, 94 pp (1981)  
UM 8114616

**Key Words:** Tanks (containers), Storage tanks, Underwater structures, Seismic response

The primary goal of this study is to perform a preliminary investigation of the seismic response of submerged, underwater oil storage tanks. The tanks under consideration have the simple shape of a vertical circular cylinder fixed at the support, completely sealed and completely filled with oil and water at all times. Because of the simple geometry, analytical solutions in series form are obtained for the fluid motion both inside and outside the tank. The flexibility of the tank is next introduced and the interaction between the fluids and the tank is considered.

#### 82-404

##### **Transient Response of a Pulsed Spherical Shell Surrounded by an Infinite Elastic Medium**

T.A. Duffey and J.N. Johnson

Los Alamos Natl. Lab., Los Alamos, NM 87545,  
Intl. J. Mech. Sci., 23 (10), pp 589-593 (1981) 4  
figs, 1 table, 6 refs

**Key Words:** Shells, Spherical shells, Elastic media, Wave propagation, Step functions, Transient response

The transient response of a pulsed spherical elastic shell surrounded by an infinite elastic medium is determined in terms of elementary functions for the case of a Heaviside step pressure pulse applied uniformly over the inner boundary of the shell. A number of specific examples of steel shells embedded in concrete and sandstone are examined for a range of shell radius-to-thickness ratios.

#### **PIPES AND TUBES**

(Also see Nos. 287, 352, 353, 376, 377, 395)

#### 82-405

##### **Experimental Benchmark for Piping System Dynamic-Response Analyses**

Advanced Reactors Div., Westinghouse Electric Corp.,  
Madison, PA (Presented at the ASME PVP conference,  
Denver, CO, June 21, 1981, 9 pp)  
CONF-810625-13

**Key Words:** Piping systems, Dynamic tests, Testing techniques

This paper describes the scope and status of a piping system dynamics test program. A 0.20 m (8 in.) nominal diameter test piping specimen is designed to be representative of main heat transport system piping of LMFBR plants. Particular attention is given to representing piping restraints. Applied loadings consider component-induced vibration as well as seismic excitation. The principal objective of the program is to provide a benchmark for verification of piping design methods by correlation of predicted and measured responses. Pre-test analysis results and correlation methods are discussed.

#### 82-406

##### **Sound Transmission through a Cylindrical Pipe Wall**

A.C. Fagerlund and D.C. Chou

Fisher Controls Co., Marshalltown, IA, ASME Paper No. 80-WA/NC-3

**Key Words:** Pipes (tubes), Cylinders, Sound transmission

A theory is developed for predicting the limiting transmission loss of sound through pipe wall. The approach is general to allow an evaluation of the effects of the internal and external fluids as well as the basic physical characteristics of the cylinder. The effects of internal static pressure and the presence of a uniform flow are also discussed. Results of an experimental program are presented which verify the theory for standard commercial pipes.

#### 82-407

##### **Linear and Non-Linear Pulse Propagation in Fluid-Filled Compliant Tubes**

D.W. Barclay, T. Bryant Moodie, and V.P. Madan  
Dept. of Math. and Stats., Univ. of New Brunswick,  
Fredericton, Canada E3B 5A3, *Meccanica*, **16** (1),  
pp 3-9 (Mar 1981) 5 figs, 13 refs

**Key Words:** Tubes, Fluid-filled containers, Pulse excitation

Impact-initiated disturbances in fluid-filled elastic tubes were studied. The undeformed tube diameter, wall thickness, and elastic modulus of the tube material are assumed to be functions of the distance along the center line of the tube.

#### 82-408

##### **Seismic Design of Clevis Assemblies for Pipe Supports**

R.A. Johnson and L.K. Severud  
Hanford Engrg. Development Lab., Richland, WA,  
Rept. No. CONF-810625-5, 18 pp (Jan 14, 1981)  
HEDL-SA-2277-FP

**Key Words:** Supports, Pipes (tubes), Seismic design, Nuclear power plants

Changes occurring during the construction of a large power plant often require upgrading of previously installed hardware. Analytically derived load ratings for pipe support structures may often be substantially increased by using test techniques. This paper describes the test methods used to increase load ratings for pipe support clevis assemblies used on the Fast Flux Test Facility.

#### 82-409

##### **Low-Level-Vibration Effects on Snubber Life**

E.J. Renkey  
Westinghouse Hanford Co., Richland, WA, Rept. No.  
HEDL-SA-2231, CONF-810625-17, 10 pp (1981)  
(Presented at the ASME PVP conference, Denver,  
CO, June 21, 1981)  
DE81023926

**Key Words:** Pipes (tubes), Seismic design

Laboratory testing has indicated that certain combinations of steady state vibration amplitudes and frequencies can reduce the life of mechanical seismic restraints. Pipe vibration testing on the FFTF plant has identified eleven hanger locations where vibration amplitudes are in an amplitude and frequency range that may lead to shorter seismic restraint life. These locations are all on accessible Secondary Heat Transport System piping. Periodic inspections have been instituted at these locations to provide early identification of damage to the seismic restraints before any pipe damage can be induced. This paper describes tests conducted to ascertain the critical range and inspection procedures instituted to identify any onset of restraint degradation.

#### 82-410

##### **Distorted Pressure Histories due to the Step Responses in a Linear Tapered Pipe (4th Report: Experimental Investigations)**

T. Tanahashi, Y. Yamashita, and S. Kawamoto  
Faculty of Science and Technology, Keio Univ.,  
Yokohoma, Japan, *Bull. JSME*, **24** (194), pp 1397-  
1404 (Aug 1981) 15 figs, 2 tables, 3 refs

**Key Words:** Pipes (tubes), Variable cross section, Step response

The wave phenomena in a linear tapered tube were experimentally investigated by the step pressure input. In this report, these experimental results were compared with the theoretical results shown in the first, second, and third reports.

#### 82-411

##### **Bottom Stability of Submarine Pipeline under Dynamic Loadings**

Y.-T. Seo

Ph.D. Thesis, The Univ. of Texas at Austin, 144 pp (1981)  
UM 8119370

**Key Words:** Pipelines, Underwater structures, Hydrodynamic excitation

The dynamic model of an unburied submarine pipeline is developed to observe the effects of hazardous loadings and end conditions of pipeline on its bottom stability. The dynamic stress distribution and bottom motion of pipeline is discussed for various wave and current condition and end condition of pipeline. The choice of weight coating and the possible failure mechanism of pipeline is presented.

#### 82-412

**Seismic Response and Fracture of Buried Pipelines**  
G.E. Muleski  
Ph.D. Thesis, Univ. of Notre Dame, 188 pp (1981)  
UM 8118580

**Key Words:** Pipelines, Underground structures, Seismic response, Shells, Cylindrical shells

A circular cylindrical shell model of a buried pipeline is developed, in conjunction with modeling of the surrounding soil and the motion of the ground. This shell model is necessary for the analysis of two failure modes associated with buried pipes subjected to seismic excitations, namely buckling and brittle fracture.

#### 82-413

**Studies on Stability of Two-degree-of-freedom Articulated Pipes Conveying Fluid (Effect of an Attached Mass and Damping)**  
Y. Sugiyama and T. Noda  
Faculty of Engineering, Tottori Univ., Koyama, Tottori, Japan, Bull. JSME, 24 (194), pp 1354-1362 (Aug 1981) 9 figs, 18 refs

**Key Words:** Pipes (tubes), Fluid-filled containers, Two-degree of freedom systems, Internal damping, Lumped parameter method, Flutter

Effect of an attached mass and damping on the stability of cantilevered articulated pipes conveying fluid is studied theoretically and experimentally in the case of two degrees of freedom.

#### 82-414

**Piping Vibrations Measured During FFTF Startup**  
M.J. Anderson  
Hanford Engrg. Dev. Lab., Richland, WA, Rept. No. CONF-810625-4, 14 pp (Mar 1981) (Presented at the ASME PVP conference, Denver, CO, June 21, 1981)  
HEDL-SA-2282

**Key Words:** Piping systems, Vibration tests, Vibration measurement, Fluid-induced excitation, Springs (elastic), Supports

An extensive vibration survey was conducted on the Fast Flux Test Facility piping during the plant acceptance test program. The purpose was to verify that both mechanical and flow induced vibration amplitudes were of sufficiently low level so that pipe and pipe support integrity would not be compromised over the plant design lifetime. Excitation sources included main heat transport sodium pumps, reciprocating auxiliary system pumps, EM pumps, and flow oscillations. Pipe sizes varied from one-inch to twenty-eight inches in diameter. This paper describes the test plan; the instrumentation and procedures utilized; and the test results.

#### 82-415

**Criteria for Accepting Piping Vibrations Measured During FFTF Plant Startup**  
S.N. Huang  
Hanford Engrg. Dev. Lab., Richland, WA, Rept. No. CONF-810625-6, 10 pp (Mar 1981)  
HEDL-SA-2279

**Key Words:** Piping systems, Vibration tests, Fluid-induced excitation

Piping in the Fast Flux Test Facility is subjected to low-amplitude, high cycle vibration over the plant lifetime. Excitation sources include the mechanical vibration induced by main centrifugal pumps, auxiliary reciprocating pumps, EM pumps and possible flow oscillations. Vibration acceptance criteria must be established which will prevent excessive pipe and support fatigue damage when satisfied. This paper describes the preparation of such criteria against pipe failure used for acceptance testing of the Fast Flux Test Facility main heat transport piping.

#### 82-416

**Influence of Compressibility of Oil on the Step Response of Hydraulic Servomechanism, 1st Report, Basic Equations and Responses under Simple Loads**  
E. Urata and T. Koyama

College of Engrg., Kanagawa Univ., Rokkakubashi 3-27, Kanagawa-ku, Yokohama, 221 Japan, Bull. JSME, 24 (194), pp 1413-1418 (Aug 1981) 5 figs, 7 refs

**Key Words:** Hydraulic servomechanisms, Stability, Step response

A step response of hydraulic servomechanism under influence of compressibility of oil is studied. The response under constant loading force is similar to the response without loading. When a few parameters are transformed suitably, the response with constant load or the Coulomb friction coincides with the response of the no-load system.

**82-417**

**Influence of Compressibility of Oil on the Step Response of Hydraulic Servomechanism, 2nd Report, The Response without Inertia Loading**

E. Urata

College of Engrg., Kanagawa Univ., Rokkakubashi 3-27, Kanagawa-ku, Yokohama, 221 Japan, Bull. JSME, 24 (194), pp 1419-1424 (Aug 1981) 11 figs, 1 ref

**Key Words:** Hydraulic servomechanisms, Stability, Step response

Step responses of the hydraulic servomechanism under spring load, viscous load and orifice load are studied considering the influence of the compressibility of oil.

**82-418**

**Measurement of the Frequency Response for a Pressure Tube/Transducer Assembly**

H. Lyttle and C. Woodward

Dept. of Aeronautical Engrg., Bristol Univ., UK, Rept. No. BU-255, 55 pp (June 1980)  
N81-24476

**Key Words:** Tubes, Frequency response, Natural frequencies

The effects of variations in tubing length and diameter were studied. A pure tone sound generator was the source of original pressure fluctuation. Such systems display many degrees of freedom, but it is found that the frequency response in the region of the lowest natural frequency can be approximated by a simple second-order system and an attempt is made to fit the measured data to such a model.

**82-419**

**Axissymmetric Propagation of a Spherical N Wave in a Cylindrical Tube**

R.D. Essert, Jr.

Applied Res. Labs., Texas Univ. at Austin, Rept. No. ARL-TR-81-22, 167 pp (May 4, 1981)  
AD-A099 990

**Key Words:** Tubes, Cylindrical shells, Wave propagation

An experimental and theoretical study of the propagation of a spherical N wave in a rigid cylindrical tube is presented. A numerical propagation algorithm, which includes nonlinear propagation distortion, has been proposed. A qualitative rendering of the algorithm accounts reasonably well for the observed changes in wave shape.

**82-420**

**Axial Restraint of Tubes in a U-Tube Type Steam Generator**

J.C. Simonis and A.F.J. Eckert

Southwest Res. Inst., San Antonio, TX, ASME Paper No. 81-DET-38

**Key Words:** Tubes, Boilers, Vibration tests

An experimental technique was developed to evaluate the axial restraint of statistically selected tubes in completed steam generators. The technique was based upon measuring the acceleration response of an individual tube span excited by a shaped impulsive force.

**82-421**

**Flow-Induced Tube Vibration Tests of Typical Industrial Heat Exchanger Configurations**

H. Halle, M.W. Wambsganss, and J.M. Chenoweth  
Argonne Natl. Lab., Argonne, IL, ASME Paper No. 81-DET-37

**Key Words:** Heat exchangers, Tubes, Fluid-induced excitation, Vibration tests

The occurrence of potentially damaging tube vibration as a function of flow rate is investigated experimentally for typical industrial shell-and-tube heat exchanger configurations. The tests use a 0.6-m (24-in.)-dia, 3.7-m (12-ft)-long heat exchanger shell containing a removable tube bundle whose component tubesheet, baffles, and tubes are readily rearranged or replaced to provide different testing configurations.

## DUCTS

(Also see No. 346)

82-422

### Acoustic Propagation in Nonuniform Circular Ducts Carrying Near Sonic Mean Flows

J.J. Kelly

Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 150 pp (1981)

UM 8118699

**Key Words:** Ducts, Elastic waves, Sound waves, Wave propagation

A linear model based on the wave-envelope technique is used to study the propagation of axisymmetric and spinning acoustic modes in hard-walled and lined nonuniform circular ducts carrying near sonic mean flows. This method is valid for large as well as small axial variations, as long as the mean flow does not separate.

## BUILDING COMPONENTS

(Also see No. 540)

82-423

### Coupling Loss Factors for Statistical Energy Analysis of Sound Transmission at Rectangular Structural Slab Joints, Part I

W. Wöhle, T. Beckmann, and H. Schreckenbach

Sektion Informationstechnik, Technische Universität Dresden, Dresden, Deutsche Demokratische Republik, *J. Sound Vib.*, 77 (3), pp 323-334 (Aug 8, 1981)

10 figs, 9 refs

**Key Words:** Structural members, Walls, Joints (junctions), Sound transmission, Statistical energy methods

Statistical energy analysis (SEA) has proved to be a promising approach to the calculation of sound transmission in complex structures. When the influence of the flanking walls is also to be included in the calculation of sound transmission in buildings the coupling loss factors at the slab joints have to be known. In this paper a generally valid method for calculating the coupling losses at a rectangular slab junction for incident bending, longitudinal and transverse waves is presented. Springs existing at the coupling point as well as potential losses are taken into consideration.

82-424

### Coupling Loss Factors for Statistical Energy Analysis of Sound Transmission at Rectangular Structural Slab Joints, Part II

W. Wöhle, T. Beckmann, and H. Schreckenbach

Sektion Informationstechnik, Technische Universität Dresden, Dresden, Deutsche Demokratische Republik, *J. Sound Vib.*, 77 (3), pp 335-344 (Aug 8, 1981)

10 figs, 1 table, 7 refs

**Key Words:** Structural members, Walls, Joints (junctions), Statistical energy methods

For use in calculating flanking sound transmission in structures by means of statistical energy analysis (SEA) coupling loss factors for the structure-borne sound transmission at rectangular structural slab joints have been calculated in Part I of this paper. These calculations are valid only for the case when the emitting slab is excited by free bending waves exclusively. In the practical case of air-borne sound excitation of a slab, the wave field of the slab, in part, consists of forced bending waves. This paper, Part II, deals with structure-borne sound transmission induced by forced bending waves and how this form of sound transmission should be taken into consideration in the SEA model.

82-425

### Study of Noise Reduction Characteristics of Multilayered Panels and Dual Pane Windows with Helmholtz Resonators

R. Navaneethan

Flight Res. Lab., Kansas University/Center for Research, Inc., Lawrence, KS, Rept. No. NASA-CR-164370, KU-FRL-417-16, 176 pp (May 1981)

N81-24857

**Key Words:** Noise reduction, Panels, Layered materials, Windows, Helmholtz resonators

The experimental noise attenuation characteristics of flat, general aviation type, multilayered panels are discussed. Experimental results of stiffened panels, damping tape, honeycomb materials and sound absorption materials are presented. Single degree of freedom theoretical models were developed for sandwich type panels with both shear resistant and nonshear resistant core material. The concept of Helmholtz resonators used in conjunction with dual panel windows in increasing the noise reduction around a small range of frequency was tested. It is concluded that the stiffening of the panels either by stiffeners or by sandwich construction increases the low frequency noise reduction.

# DYNAMIC ENVIRONMENT

## ACOUSTIC EXCITATION

(Also see No. 551)

**82-426**

### A Summary of Recent Results in Acoustic Bottom Interaction Research

P.J. Vidmar, R.A. Koch, J.F. Lynch, and K.E. Hawker

Appl. Res. Labs., Texas Univ. at Austin, TX, Rept. No. ARL-TR-81-11, 35 pp (Mar 1981)  
AD-A099 531

**Key Words:** Underwater sound, Reviews

This report summarizes research on acoustic interaction with the sea floor carried out during 1980 at Applied Research Laboratories, The University of Texas at Austin. Major topics considered are generic geoaoustic profiles for single layer sediment structures and propagation in a range variable environment. Other topics include the effects of bottom roughness (scattering) and the bottom interaction phase shift.

**82-427**

### Acoustic Radiation from a Moving Line Source

K. Tanaka and S. Ishii

Dept. of Industrial-Mech. Engrg., Nagoya Inst. of Tech., Nagoya, Japan, J. Sound Vib., 77 (3), pp 397-401 (Aug 8, 1981) 2 figs, 5 refs

**Key Words:** Sound waves, Moving loads, Line source excitation

This paper is concerned with an acoustic field which is caused by a harmonic line source moving with uniform velocity through an infinite medium at rest. This problem is closely related to that of acoustic radiation from a stationary line source in a flow of uniform velocity, which is of particular interest in aeroustics. The analysis is facilitated by the use of the Green function method. The perturbation pressure at a stationary point is evaluated.

**82-428**

### Inversion of the First-Order Equations Governing

### the Propagation of Sound Waves in a Layered Acoustic Medium

M.S. Howard

Ph.D. Thesis, Indiana Univ., 103 pp (1981)

UM 8119028

**Key Words:** Sound waves, Wave propagation, Layered materials

The inverse scattering problem for a layered acoustic medium is considered from the first-order differential equations of motion, resulting in a vector formulation of the problem, and using a vector form of the inverse scattering methods for Schrodinger's equation of Quantum Mechanics. The result is a vector Marchenko equation.

**82-429**

### Surface Acoustic Wave Measurements of Surface Cracks in Ceramics

J.J.W. Tien, B.T. Khuri-Yakub, G.S. Kino, D.B. Marshall, and A.G. Evans

Edward L. Ginzton Lab. of Physics, Stanford Univ., CA, 70 pp (June 1981)

AD-A101 241

**Key Words:** Sound waves, Elastic waves, Wave propagation, Cracked media, Ceramics

An investigation of scattering from surface cracks has been conducted. In particular, the change in the reflection coefficient of a Rayleigh wave incident on a surface indentation crack has been measured as the sample is stressed to fracture. The acoustic measurements have been correlated with the stable crack extension that precedes final failure.

**82-430**

### Comments on the Relation Between Surface Wave Theory and the Theory of Reflection

V.I. Alshits and J. Lothe

Inst. of Crystallography, Academy of Science, Moscow, USSR, Wave Motion, 3(4), pp 297-310 (Oct 1981) 3 figs, 12 refs

**Key Words:** Wave propagation, Wave reflection, Elastic waves

The sextic Stroh formalism, previously extensively used in the analysis of subsonic phenomena, has been used for the analysis of reflection phenomena and leaky surface waves in the first transonic range of velocities. In particular the

behavior of the reflection problem at the limiting velocity is studied. It is shown that when the condition of free surface can be satisfied without the inhomogeneous partial wave, a situation which would appear to be the natural limiting case of a surface wave of infinite penetration, the body wave alone satisfies the condition of free surface.

#### 82-431

##### **Analysis of Physical Optics Far Field Inverse Scattering for the Limited Data Case Using Radon Theory and Polarization Information**

W.-M. Boerner and C.-M. Ho

Communications Lab., Information Engrg. Dept., SEO-1104, Univ. of Illinois at Chicago Circle, Chicago, IL 60680, Wave Motions, 3 (4), pp 311-333 (Oct 1981) 7 figs, 32 refs

**Key Words:** Wave propagation, Wave diffraction, Time domain method, Frequency domain method

In the inverse scattering problem for perfectly conducting objects, the reconstruction of the shape and size of a convex body from its cross-sectional areas has been formulated as a Radon problem of shape reconstruction from projections. It is shown here that the physical optics inverse scattering time-domain and frequency-domain identities from a Radon-Fourier transform pair, and the problem of target reconstruction from incomplete data is common to both. The mathematical aspects of reconstruction from projections are examined using concepts of Radon's theory, and the sparse aspect data problem is analyzed. The technique is applied to the case of a sphere-capped cylinder and the results show substantial improvement over previous scalar approaches.

#### 82-432

##### **Blast Noise Prediction. Volume I. Data Bases and Computational Procedures**

P.D. Schomer, L.L. Little, D.L. Effland, V.I. Pawlowska, and S.G. Roubik

Construction Engrg. Res. Lab. (Army), Champaign, IL, Rept. No. CERL-TR-N-98, 76 pp (Mar 1981) AD-A099 440

**Key Words:** Noise generation, Blast loads, Noise prediction, Weapons effects, Data processing, Computer programs

Over the past several years, the Construction Engineering Research Laboratory has gathered data from various sources dealing with blast noise generation and propagation and has performed several sets of field measurements designed to

enhance this data base. These studies have been performed as a part of efforts aimed at improving methods of predicting the noise impact of military installations. Specifically included are measurements of the directivity pattern of major Army weapons and the statistical propagation and blast noise in the atmosphere. Volume I of this report develops and explains the relations among the various data bases which have been developed to predict blast noise impact of Army facilities. From these studies, data bases and computational procedures which are used within the Blast Noise Prediction computer program (BNOISE 3.2) are developed.

#### 82-433

##### **On the Generation of Side-Edge Flap Noise**

M.S. Howe

Bolt, Beranek and Newman, Inc., Cambridge, MA, Rept. No. NASA-CR-3437, 46 pp (June 1981) N81-24853

**Key Words:** Noise generation, Airfoils

A theory is proposed for estimating the noise generated at the side edges of part span trailing edge flaps in terms of pressure fluctuations measured just in-board of the side edge of the upper surface of the flap. Asymptotic formulae are developed in the opposite extremes of Lorentz contracted acoustic wavelength large/small compared with the chord of the flap. Interpolation between these limiting results enables the field shape and its dependence on subsonic forward flight speed to be predicted over the whole frequency range.

#### 82-434

##### **Vortex Shedding as a Source of Acoustic Energy in Segmented Solid Rockets**

R.S. Brown, R. Dunlap, S.W. Young, and R.C. Waugh  
United Technologies, Sunnyvale, CA, J. Spacecraft Rockets, 18 (4), pp 312-319 (July-Aug 1981) 15 figs, 4 tables, 17 refs

**Key Words:** Vortex shedding, Solid propellant rocket engines, Acoustic excitation, Fluid-induced excitation

Discrepancies have been observed between the predicted and measured combustion-stability characteristics of the full-scale and subscale Titan segmented solid-propellant rocket motors. Pressure oscillations were generated under conditions which cannot be explained analytically, even allowing for inaccuracies in the propellant parameters. Furthermore, the predicted trend of the acoustic frequency with time is not

consistent with the observed trend. This suggests an important source of acoustic energy has been omitted from the analysis. Experimental studies were conducted to examine periodic vortex shedding as an additional source of acoustic energy. These tests were conducted in a cold-flow model of the full-scale Titan SRM. The results demonstrate that periodic flow separations can produce significant pressure oscillations when the shedding frequency approximates the classical acoustic frequency.

**82-435**

**A Fundamental Study on Frictional Noise (3rd Report, The Influence of Periodic Surface Roughness on Frictional Noise)**

M. Yokoi and M. Nakai

Junior College, Osaka Industrial Univ., 3-1-1 Nakagaido Daito-city, Osaka, Japan, Bull. JSME, 24 (194), pp 1470-1476 (Aug 1981) 13 figs, 1 table, 6 refs

**Key Words:** Rods, Friction excitation, Noise generation, Surface roughness

Experimental and theoretical studies have been done on frictional noise when a steel rod is pressed in the radial direction on a rotating thick disk with periodic corrugation surface without lubrication. When the surface roughness become larger, various resonances were observed.

**82-436**

**A Fundamental Study on Frictional Noise (4th Report, The Influence of Angle of Inclination of the Rod on Frictional Noise)**

M. Yokoi and M. Nakai

Junior College, Osaka Industrial Univ., 3-1-1 Nakagaido Daito-city, Osaka, Japan, Bull. JSME, 24 (194), pp 1477-1483, 9 figs, 2 tables, 6 refs

**Key Words:** Rods, Friction excitation, Noise generation

Frictional noise was studied experimentally and theoretically, when a steel rod fixed at one end is pressed in the radial direction on a rotating thick disk without lubrication with an angle of inclination. When the rod is inclined to the same direction of the rotation of the disk, rubbing and squeal noise occur and their frequencies become larger with an increase of the rod angle.

**82-437**

**Temporal Sampling Requirements for Estimating the Mean Noise Level in the Vicinity of Military Installations**

P.D. Schomer, R.E. DeVor, W.A. Kline, R.J. Lauson, and R.D. Neathammer

Construction Engrg. Res. Lab. (Army), Champaign, IL, Rept. No. CERL-TR-N-101, 174 pp (Apr 1981) AD-A099 801

**Key Words:** Military facilities, Noise prediction

High sound exposure levels in the vicinity of military installations are an increasingly important acoustics problem, especially with the recent emphasis on the establishment of environmental standards. This research addresses the problem of using monitored data to establish estimates of long-term average noise levels which can be determined with prespecified levels of precision and statistical significance. Daily average noise-level data exhibit characteristics amenable to time series modeling. The Dynamic Data System method is used to characterize noise data by autoregressive-moving average models for the purpose of determining the variance of the sample mean of such data so that sampling requirements can be derived.

## SHOCK EXCITATION

(Also see Nos. 432, 459)

**82-438**

**Computation of Impulse Control Laws for a Non-linear Stochastic Oscillator**

Y. Yavin and A. Venter

Natl. Res. Inst. for Mathematical Sciences, Pretoria, South Africa, Rept. No. CSIR-TWISK-143, 26 pp (Mar 1980) N81-25303

**Key Words:** Oscillators, Impulse intensity

Impulse control theory is applied in order to improve the performance of nonlinear stochastic second order system representing a sine wave oscillation. This is done in two stages. First the equations of optimal impulse control are introduced and a closed-form solution is given to the equations on the closed exterior of a circular disk in the  $X_1$ - $X_2$  plane. Then a finite-difference scheme is suggested for solving the equations, and they are given numerically, for a number of cases on the inside of the disk. During both stages, the action set on which an impulse is applied by the system is obtained throughout the solution.

82-439

**Impact Response of a Penny-Shaped Crack Placed Parallel to the Boundary of an Infinite Slab**

R.B. Mohapatra and H. Parhi

Dept. of Math., Regional Engrg. College, Rourkela-769008, India, *Intl. J. Solids Struc.*, 17 (11), pp 1037-1042 (1981) 4 refs, 1 table, 7 refs

**Key Words:** Slabs, Cracked media, Discontinuity-containing media, Impact response

The axisymmetric dynamical problem is presented for an infinite slab weakened by a penny-shaped crack. The crack is assumed to be opened by the application of a step stress. Laplace and Henkel transform techniques are used to reduce the problem to the solution of a Fredholm integral equation of the second kind in a transformed plane. Finally the problem is solved by a special numerical Laplace inversion technique. Numerical results on the dynamic stress-intensity factor are obtained. The influence of inertia, finite boundaries and their interactions on the load transfer to the crack are considered.

82-440

**Impact Resistance of Fibre Concrete**

A.P. Hibbert and D.J. Hannant

Transport and Road Res. Lab., Crowthorne, UK, Rept. No. TRRL-SUPPLEMENTARY-654, 31 pp (1981) PB81-228165

**Key Words:** Concretes, Fiber composites, Energy absorption, Fracture properties, Impact tests

A description is given of the determination of the impact energy of concrete reinforced with discontinuous fibers of steel or twisted fibrillated polypropylene film. The design and instrumentation of a Charpy type of pendulum impact test machine is outlined, the machine being capable of completely fracturing in a single blow fiber concrete beams measuring 100 x 100 x 500 mm. This machine was used to determine the energy absorbed in the fracture process, both from the amplitude of the pendulum swing and also from the record of force developed on the pendulum head during the impact. The latter method enabled the energy absorption to be determined with respect to the central deflection of the test beam in a manner analogous to energy determination from the area under a conventional slow-rate-load-deflection curve. A variety of steel fiber types and two lengths of chopped fibrillated polypropylene film were used to produce composites with two fiber volume fractions and these were tested at two ages.

82-441

**Transient Analysis of Shear Impact of an Elastic Half Space**

T. Jingu and E. Tsuchida

Faculty of Engrg., Gunma Univ., Kiryu, Japan, *Bull. JSME*, 24 (194), pp 1346-1353 (Aug 1981) 8 figs, 12 refs

**Key Words:** Half-space, Impact response, Stress waves, Wave propagation

This paper presents a transient analysis of the propagation of stress waves arising in an elastic half-space subjected to concentrated tangential force varying with the Heaviside unit step function on the surface. The results of numerical evaluation are shown graphically as the relation of the displacement and the stress variations versus time in an elastic half-space.

82-442

**Effects of Cavitation on Underwater Shock Loading-Plane Problem**

R.E. Newton

Naval Postgraduate School, Monterey, CA, Rept. No. NPS-69-81-001A, 35 pp (Mar 1981) AD-A099 792

**Key Words:** Cavitation, Underwater explosions, Underwater structures, Submerged structures

Final results of an investigation of the effects of response-induced cavitation on underwater shock loading are reported. Data were obtained by finite element modeling of a submerged sandwich shell and a surrounding plane fluid region. Representative curves are presented showing shell bending stress, hoop compressive stress and contents acceleration as functions of time. It is concluded that, for the range of parameters considered, cavitation does not increase the severity of loading on structure or equipment.

82-443

**Dynamic Analysis to Establish Normal Shock and Vibration of Radioactive Material Shipping Packages**

S.R. Fields

Hanford Engrg. Development Lab., Richland, WA, Rept. No. HEDL-TME-80-72, 64 pp (Apr 1981) NUREG/CR-1685-V2

**Key Words:** Shipping containers, Radioactive materials, Railroad cars, Frequency response, Vibration response spectra, Shock response spectra

An equation of motion was derived for an equivalent single-degree-of-freedom representation of relative rotational motion between a radioactive material shipping package (cask) and its rail car (support). This equation of motion, along with those derived earlier for the relative horizontal and vertical motion, was used to construct CARRS (Cask-Rail Car Response Spectra Generator), a model to generate frequency response spectra using calculated results obtained from the CARDS (Cask Rail Car Dynamic Simulator) model. Frequency response spectra are presented for various exploratory cases. Further evaluation of the performance of CARDS was made, after insertion of the latest parameter data, by comparing calculated results with response variables measured during Test 3 of the series of tests conducted at the Savannah River Laboratories.

**82-444**

**An Investigation of Steady High-speed Compressible Flow Characteristics through Pipe Orifice by Shock Tube Analogy**

S. Itoh, Y. Torizumi, A. Kitamura, and M. Itaya  
Dept. of Mech. Engrg., Kyushu Sangyo Univ., Matsugadai Higashi-Ku Fukuoka, Japan, Bull. JSME, 24 (194), pp 1405-1412 (Aug 1981) 14 figs, 13 refs

**Key Words:** Shock tube testing

This paper describes in detail some investigations relating to shock tube orifice flow experiments and model calculations. The accuracy of the analytical results of the model have been checked by shock tube experiments.

**82-445**

**Prediction of Explosively Driven Relative Displacements in Rocks**

S. Blouin  
Cold Regions Res. and Engrg. Lab., Hanover, NH, Rept. No. CRREL-81-11, 31 pp (June 1981)  
AD-A101 314

**Key Words:** Explosions, Nuclear explosions, Rocks

Relative displacement data from high explosive, shallow-buried bursts in rock are combined with relative displacement data from the contained nuclear explosion MIGHTY EPIC. Analysis of these data yields a preliminary, semi-empirical

technique for predicting the location, direction and magnitude of relative displacements in rock from contained explosions. This technique is used to make relative displacement predictions for the DIABLO HAWK nuclear blast.

**82-446**

**Response of Multiple Coupled Dynamic Systems**

L.J. Maga  
Ph.D. Thesis, The Catholic Univ. of America, 155 pp (1981)  
UM 8118985

**Key Words:** Coupled response, Impact response

The impulse response function of multiple, generally coupled, one-dimensional, wave-bearing, dynamic systems is determined in terms of the reflection and transmission coefficients at the boundaries of each system. The impulse response function is described in the spatial-frequency space. The description can handle a complex dynamic system consisting of many basic dynamic systems coupled in various configurations, i.e., a starlike configuration, a cascade configuration, or combinations of these. The description is shown to reduce properly to descriptions derived previously to fit specific models of simplified complexes.

**82-447**

**Strain-Rate Effects in Beryllium under Shock Compression**

J.R. Asay, L.C. Chhabildas, and J.L. Wise  
Rept. No. SAND-80-2847C, CONF-810684-13, 5 pp (1980) (Presented at APS Conference on Shock Waves in Condensed Matter, Menlo Park, CA, June 23, 1981)  
DE81024080

**Key Words:** Shock wave propagation, Metals

Shock wave experiments were conducted on beryllium over the range of 6 to 25 GPa. A steady wave analysis of the shock front was used to estimate effective viscosities achieved during the loading process, which were found to vary approximately as the inverse square root of strain rate for strain rates greater than about  $3 \mu s^{-1}$ .

**82-448**

**Computer Simulation of Detonation Waves**

N. Hoernqvist and J. Persson

Foersvarets Forskningsanstalt, Stockholm, Sweden,  
Rept. No. FOA-C-20390-A2, 18 pp (Dec 1980)  
N81-27383

**Key Words:** Shock waves, Simulation, Computer-aided techniques

Results from computerized simulation of the detonation wave generated by a high explosive (TNT) are compared with the theoretical solution. The number of mesh points needed to model the detonation wave and the time necessary for establishing its presence are found.

**82-449**

**A Review of Wave Motion in Anisotropic and Cracked Elastic-Media**

S. Crampin

Inst. of Geological Sciences, Murchison House, West Mains Rd., Edinburgh EH9 3LA, UK, Wave Motion, 3 (4), pp 343-391 (Oct 1981) 10 figs, 7 tables, 83 refs

**Key Words:** Wave propagation, Seismic waves, Anisotropy

Recent developments in the theory and calculation of wave propagation in anisotropic media have been published in the geophysical literature and refer specifically to seismological applications. Anisotropic phenomena are comparatively common, and it is the intention of this review to present these developments to a wider audience. Few of the results are new, but the opportunity is taken to tidy up a few loose ends, and present consistent theoretical formulations for the numerical solution of a number of propagation problems. Such numerical experiments have played a large part in our increasing understanding of wave motion in anisotropic media. It now appears that the solution of most problems in anisotropic propagation can be formulated, if the corresponding solution exists for isotropic propagation, and may be solved at the cost of considerably more numerical computation.

**82-450**

**Analysis of Local Variations in Free Field Seismic Ground Motion**

J.-C. Chen, J. Lysmer, and H.B. Seed

Earthquake Engrg. Res. Ctr., California Univ., Berkeley, Rept. No. UCB/EERC 81/03, ARO-13838.2-GS, 283 pp (Jan 1981)  
AD-A099 508

**Key Words:** Interaction: soil-structure, Seismic response, Ground motion

Earthquake engineers are often faced with the problem of determining the temporal and spatial variation of near-surface seismic motions in a site. This type of information is needed for the evaluation of soil-structure interaction effects, liquefaction potential and the effects of local site conditions on surface motions. The research involved five phases: review of current knowledge, development of new methods of site response analysis, application to site response analysis, application to soil-structure interaction analysis, and evaluation of the relative importance of horizontally propagating waves in engineering design.

**82-451**

**Seismic Indexing System for Army Installations. Volume 1. Real Property Inventory Screening Procedure**

J.D. Prendergast and W.E. Fisher

Army Construction Engrg. Res. Lab., Champaign, IL, Rept. No. CERL-TR-M-290-VOL-1, 58 pp (May 1981)

AD-A101 194

**Key Words:** Military facilities, Seismic analysis

This report deals with the Army's capability to economically identify and evaluate the seismic capacity and strengthening strategies for essential and high potential loss facilities at Army installations, i.e., Mission Affordable Seismic Strengthening (MASS). One of the technological needs to achieve MASS is the development of a facility seismic hazard indexing procedure to identify existing facilities that are potentially seismically hazardous based on the information in the real property inventory for Army installations. The real property inventory screening procedure described in this volume is an integral part of the facility seismic hazard indexing procedure. The screening procedure is necessary in order to reduce inventoried buildings to a more manageable number; and to aid in identifying the more important buildings on the basis of user-specified criteria for the earliest date of acquisition, minimum acquisition cost, and minimum building area. The screening procedure excludes from the real property inventory those buildings which do not conform with the specified criteria, and provides listings of the buildings remaining in the inventory in formats and sequences that will help in setting priorities for conducting seismic safety evaluations. However, the screening procedure does not include seismic hazard priority-ranking of the results nor does it adjust the acquisition costs to reflect the effects of inflation.

**82-452**

**Seismic Indexing System for Army Installations. Vol-**

**ume II. Seismic Hazard Priority-Ranking Procedure for Army Buildings: Basic Concept**

J.D. Prendergast and W.E. Fisher

Army Construction Engrg. Res. Lab., Champaign, IL, Rept. No. CERL-TR-M-290-VOL-2, 67 pp (May 1981)

AD-A101 194

**Key Words:** Military facilities, Buildings, Seismic analysis

This report deals with the Army developed capability to economically identify and evaluate the seismic capacity and strengthening strategies for essential and high potential loss facilities at Army installations, i.e., Mission Affordable Seismic Strengthening (MASS). One of the technological needs to achieve MASS is the development of a facility seismic hazard indexing procedure to identify existing facilities that are potentially seismically hazardous based on the information in the real property inventory for Army installations. The basic concept of a seismic hazard priority-ranking procedure for Army buildings described in this volume is an integral part of the facility seismic hazard indexing procedure. The basic concept provides the framework for a preliminary, subjective seismic safety evaluation of existing Army buildings based on an analysis of the information contained in the inventory of Army military real property and the anticipated seismic exposure hazard. Further development of the basic concept is required to refine the basic indices, to establish weighting factors, and to automate the concept.

82-353

**An Earthquake Engineering Wave Propagation Model**

A. Castellani, C. Chesi, and E. Mitsopoulou

Politecnico di Milano, Italy, *Meccanica*, 16 (1), pp 33-41 (Mar 1981) 12 figs, 17 refs

**Key Words:** Soils, Seismic analysis, Wave propagation, Boundary value problems, Finite element technique

A finite element model for the seismic behavior of soils requires the definition of suitable boundary conditions to simulate the surrounding soil. These conditions are here analyzed theoretically under the only assumption that the boundary soil behaves elastically. Their application requires the definition of the wave direction. The one of impinging waves is known, being an input datum; the one of the outcoming waves is in general not known a priori. The amount of errors involved is discussed. An analogous problem was previously dealt with for sources of disturbances interiors to the represented portion of the space.

82-454

**International Seismological Data Center: Compilation of Identification Data**

H. Israelson

Foersvarets Forskningsanstalt, Stockholm, Sweden, Rept. No. FOA-C-20384-T1, 33 pp (Nov 1980)

N81-27738

**Key Words:** Nuclear explosion detection, Data processing

The problem of compiling data for identifying seismic events is addressed. Such data compilation would be conducted by special international data centers as part of a system to monitor compliance with a comprehensive test ban on underground nuclear explosions. Temporary international seismological data center facilities were set up at the Hagfors Observatory. Identification parameters were limited to short period P waves. Results illustrate the necessity of introducing station corrections before compiling multistation data for a seismic event.

82-455

**Project PROPA-GATOR: Intermediate Range Explosion Airblast Propagation Measurements**

J.W. Reed

Sandia Natl. Labs., Albuquerque, NM, Rept. No. CONF-800941-3, CONF-810371-1, 20 pp (1980) (Presented at DOD Explosives Safety Seminar, Los Angeles, CA, Sept 9, 1980)

SAND-80-1880C

**Key Words:** Air blast, Shock wave propagation, Experimental test data

Several hundred explosions of flaked TNT, ranging in charge weight from 2.3 kg to 1145 kg were fired at the NASA Kennedy Space Center, Florida, in March and June, 1979. Comprehensive meteorological measurements were made by rawinsonde balloons and on a nearby 150 m tower, including wings, turbulence, temperatures, and humidity. A cruciform array of airblast gages was operated, with gages at 200 m, 500 m, 1 km, 2 km, and 5 km ranges from the explosions. For some events as many as six microbarographs were operated at distances to 25 km. Airblast results have been correlated against refractive atmospheric conditions, establishing a functional relationship between overpressure decay with distance and the sound velocity gradient with height.

**VIBRATION EXCITATION**

(Also see No. 443)

82-456

**The Determination of Mode Shapes for Dynamically Loaded Rigid-Plastic Structures**

J.B. Martin

Dept. of Civil Engrg., Univ. of Cape Town, South Africa, *Meccanica*, 16 (1), pp 42-45 (Mar 1981) 10 refs

**Key Words:** Mode shapes

Mode solutions in rigid-plastic structures subjected to fixed external loads are dynamic solutions which are products of separate functions of space and time. The paper presents a simple algorithm for the determination of mode shapes. An iterative procedure is established in which each iteration is equivalent to the solution of a static limit analysis problem. Convergence is proved.

**82-457**

**Calculation of the Frequency Responses of Complex Systems Directly from the Physical Parameters**

R.M. Goodall

British Railways Board, Railway Tech. Ctr., Derby, UK, *Trans. of the Inst. of Measurement and Control*, 2 (3), pp 164-168 (July-Sept 1980) 11 figs, 3 tables, 1 ref

**Key Words:** Frequency response

The paper describes a novel technique by which frequency responses can be calculated. It uses basic physical data of the system, and, as such, even complex systems can be rapidly modeled and analyzed. The method and its associated digital computation are inclined towards a control-engineering approach in which systems are represented by block diagram, but it will give the frequency-domain solution for any set of linear simultaneous differential equations. Examples are given for both forms of system representation to illustrate the practical use of the technique.

**82-458**

**Flutter Analysis of Two-Dimensional and Two-Degree-of-Freedom MBB A-3, CAST 7, and TF-8A Supercritical Airfoils in Small-Disturbance Unsteady Transonic Flow**

T.Y. Yang, A.G. Striz, and P. Guruswamy

School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. AFWAL-TR-81-3004, 115 pp (Mar 1981)

AD-A100 334

**Key Words:** Flutter, Airfoils, Aerodynamic loads, Computer programs

Flutter analyses at transonic Mach numbers are performed for three supercritical airfoils. For all airfoils, two degrees of freedom, pitching and plunging, are considered. The unsteady aerodynamic data are obtained. The steady aerodynamic results are shown in the form of upper and lower surface pressure curves. The unsteady aerodynamic coefficients are obtained for various values of low reduced frequencies by pitching the airfoils about the quarter chord axis.

**82-459**

**Dynamic Response of Light Equipment in Structures**

A.D. Kiureghian, J.L. Sackman, and B. Nour-Omid  
Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-81/05, NSF/ENG-81005, 63 pp (Apr 1981)

PB81-218497

**Key Words:** Coupled systems, Multi degree of freedom systems, Single degree of freedom systems, Equipment response, Seismic excitation, Natural frequencies, Mode shapes, Modal damping

Perturbation methods are employed to determine the dynamic properties of a combined system composed of a multi-degree-of-freedom structure to which is attached a light, single-degree-of-freedom equipment item. The derived properties are used to determine the response of the equipment when the structure is subjected to a random input excitation. For earthquake-type excitations, a response spectrum method is developed whereby various statistical measures of the equipment response are given directly in terms of the input ground response spectrum. Tuning and equipment-structure interaction are included. The method efficiently generates floor spectra which include the effect of interaction.

**82-460**

**The Influence of the Coulomb, Viscous and Acceleration-Dependent Terms of Kinetic Friction on the Critical Velocity of Stick-Slip Motion**

B.M. Belgaumkar

Vainatheya, Irla, Vile-Parle (West), Bombay 400056, India, *Wear*, 70 (1), pp 119-123 (July 15, 1981) 11 refs

**Key Words:** Stick-slip response, Friction

To explain the experimentally observed highly complex behavior of friction in stick-slip motion an acceleration-

dependent term with a fictitious mass is added to the friction force function in the governing equation of motion. A new concept of complex mass is introduced into the modified equation. The inertia effect and the energy-absorbing effect of the complex mass are discussed. The influences of the Coulomb and viscous terms in the friction force function are described and the nature of the influence of the acceleration-dependent term is explained.

**82-461**

**Evaluation of Two-Dimensional Subsonic Oscillatory Airforce Coefficients and Loading Distributions**

D.J. Salmond

Royal Aircraft Establishment, Farnborough, Hampshire, UK, Aeronaut. Quart., 32 (3), pp 199-211 (Aug 1981) 4 figs, 9 refs

**Key Words:** Airfoils, Stiffness coefficients, Damping coefficients, Harmonic response

A method is described for calculating numerically the aerodynamic stiffness and damping coefficients and loading distributions for a two-dimensional thin aerofoil oscillating harmonically in subsonic flow, from the Possion Integral Equation by approximating the loading by a finite series of basis functions. Sample loading distributions obtained by using the method are presented for a Mach number of 0.9 and a frequency parameter of 0.4.

**82-462**

**A Model for the Analysis of Air Heater Vibrations**

C.S. Chang and Y.G. Yeh

The Chinese Academy of Sciences, Beijing, China, ASME Paper No. 81-DET-34

**Key Words:** Heat radiators, Vibration response

A model based on mechanical waveguide theory is proposed to analyze the air heat vibrations and an attempt is made to explain some interesting phenomena observed in a full-scale air heater vibration experiment.

**82-463**

**The Dynamics of Wind-Induced Oscillations of Bluff Bodies**

A.B. Adenigba

Ph.D. Thesis, Colorado State Univ., 80 pp (1981)  
UM 8119685

**Key Words:** Flexural vibration, Cylinders, Wind-induced excitation, Bifurcation theory

The most recent and powerful techniques for handling non-linear nonconservative oscillations are the Hopf bifurcation techniques that are coming into wide use to investigate problems in fluid mechanics, wind engineering, nonlinear mechanics, biology, chemical reactor design and operation, combustion and astrophysics. Hopf bifurcation techniques involve an evaluation of certain algebraic expressions which give the local stability and direction of the bifurcating periodic solution as well as close approximations to the periodic solution near the bifurcation. The dynamical capabilities of the Iwan-Blevins model for predicting wake-vortex-induced oscillation of bluff bodies were investigated using Hopf bifurcation theory. Bifurcation, stability, direction of bifurcation, periodic orbits and response diagrams were obtained and classified. Comparison was made with experimental data of Feng. The experimentally observed double amplitude response for an elastically mounted cylinder vibrating in the transverse direction are predicted and explained. Prediction of the model and experimental results model agree within the range of experimental data scatter.

**82-464**

**On the Van der Pol Relaxation Oscillator with a Sinusoidal Forcing Term**

J. Grasman

Mathematisch Centrum, Amsterdam, The Netherlands, Rpt. No. MC-TW-207/80, 15 pp (Sept 1980)  
N81-27862

**Key Words:** Oscillators, Van der Pol oscillators, Periodic excitation, Forcing function

Asymptotic approximations of subharmonic solutions of the periodically forced Van der Pol relaxation oscillator are constructed with singular perturbation techniques. These approximations are locally valid and can take the form of a two variable expansion in one region and a boundary layer type of solution in another region. Integration constants are determined by averaging and matching conditions. The construction of the approximations brings about certain restricting conditions on the amplitude of the forcing term.

**82-465**

**Response of Self-Excited Multidegrees-of-Freedom Systems to Multifrequency Excitations**

K.R. Asfar

Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 184 pp (1981)  
UM 8118685

**Key Words:** Multidegree of freedom systems, Self-excited vibrations

The response of self-excited multidegrees-of-freedom systems of the van der Pol type to multifrequency excitations is analyzed. A first-order uniformly valid approximate solution is sought using the perturbation method of multiple scales. The analysis shows a good agreement between the predicted solution obtained via the method of multiple scales and that obtained by numerical integration of the governing differential equations. The response of self-excited systems to multi-frequency excitations can be viewed as the response of the same self-excited system subjected to a random but periodic excitation (e.g. a square wave in electric circuits) as long as all the independent excitations are in phase.

**82-466**

**An Approach for Dynamic Analysis of Mechanical Systems with Multiple Clearances Using Lagrangian Mechanics**

B.M. Bahgat, M.O.M. Osman, and T.S. Sankar  
Concordia Univ., Montreal, Canada, ASME Paper No. 81-DET-3

**Key Words:** Mechanisms, Clearance effects

The paper develops a general procedure for the dynamic analysis of planar mechanisms with multiple clearance. The analysis mainly relies on determining the clearance angles at mechanism revolutes for each phase of the analysis. The governing equations of each clearance angle is developed using Lagrangian mechanics.

Univ. of Quebec, Montreal, Quebec, Canada, J. Dyn. Syst., Meas. and Control, Trans. ASME, **103** (3), pp 290-292 (Sept 1981) 5 figs, 4 refs

**Key Words:** Dampers, Pneumatic dampers, Dashpots, Lumped parameter method, Design techniques

Cam-actuated mechanism with a pneumatic coupling is a design improvement upon the conventional system. Pneumatic dashpots are used which provide a cushioning effect, thus reducing the wear and tear of system components. This paper investigates the dynamic behavior of such a system based on a lumped parameter model with a damping factor which is a nonlinear function of the frequency. A digital computer is used as a design tool to determine the effect on the performance of changing design parameters. It is found that the system amplitude ratio peak depends largely upon the pneumatic damper orifice area and that a proper selection of the orifice area will yield a minimum resonance amplitude ratio.

**82-468**

**Finite Element for Rotor/Stator Interactive Forces in General Engine Dynamic Simulation. Part 1: Development of Bearing Damper Element**

M.L. Adams, J. Padovan, and D.G. Fertis  
Dept. of Civil Engrg., Akron Univ., OH, Rept. No. NASA-CR-165214, EDA-201-3A, 77 pp (Oct 1980) N81-27522

**Key Words:** Squeeze-film dampers, Interaction: rotor-stator, Finite element technique

A general purpose squeeze-film damper interactive force element was developed, coded into a software package (module) and debugged. This software package was applied to nonlinear dynamic analyses of some simple rotor systems. Results for pressure distributions show that the long bearing (end sealed) is a stronger bearing as compared to the short bearing as expected. Results of the nonlinear dynamic analysis, using a four degree of freedom simulation model, showed that the orbit of the rotating shaft increases nonlinearity to fill the bearing clearance as the unbalanced weight increases.

## MECHANICAL PROPERTIES

### DAMPING

**82-467**

**Analysis of a Pneumatically Coupled Cam-Actuated Mechanism**

S. LeQuoc and R.M.H. Cheng

### FATIGUE

(Also see Nos. 328, 368)

**82-469**

**Fatigue Machine Gives Quick Tests of Metal Strength**

H. Erzurum

Kent State Univ., Trumbull Campus, Warren, OH,  
Indus. Res. Dev., 23 (11), pp 154-156 (Nov 1981)

**Key Words:** Fatigue tests, Test equipment and instrumentation

A pneumatic high-speed fatigue testing machine is described. It provides simultaneous testing of as many as eight specimens, thus improving statistical results. Using this machine reproducible data can be obtained within three weeks.

**82-470**

**A Comparative Study of the Lanchester Damper and the Segmented Slug Damper in Boring Bar Applications**

G.W. Fitzgerald

Kennametal Inc., Latrobe, PA, ASME Paper No. 81-DET-90

**Key Words:** Bars, Metal working, Damping coefficients

Analytical and experimental studies have been performed to determine the damping characteristics of a 2.00 in. (50.8 mm) dia steel boring bar fitted with a Lanchester damper and a segmented slug damper. A finite element model of the boring bar was developed and used to determine the fundamental bending mode of the bar and the damping associated with the fundamental mode due to material damping and viscous damping created by the Lanchester/segmented slug damper.

**82-471**

**Fatigue Behavior of Composite Laminates**

H.T. Hahn and D.G. Hwang

Materials Res. Lab., Washington Univ., St. Louis, MO, Rept. No. AFWAL-TR-80-4172, 94 pp (Nov 1980)

AD-A101 349

**Key Words:** Layered materials, Fatigue life

The main objective of this program during the final reporting period was to investigate the fatigue behavior of a laminate through proof testing. The primary emphasis was on the delineation of the effect of proof test on the residual strength and life, the establishment of strength-life relations, and the identification of sources of scatter in strength and life. The test program consisted of static tests, tension-tension fatigue tests preceded by proof tests, and examinations of failure characteristics.

**82-472**

**Overload Retardation Models of Fatigue Crack Growth**

Y.-s. Huang, X.-h. Liu, and H.-I. Ni

Northwestern Polytechnical Univ., Acta Mechanica Solida Sinica, Chinese Soc. of Theor. and Appl. Mech., 2, pp 257-267 (1981) 9 figs, 3 tables, 19 refs (In Chinese)

**Key Words:** Fatigue life

In this paper eight overload retardation models of fatigue crack growth are reviewed. Their basic principles are treated and physical concepts explained in detail. A comparison has been made between the eight models with respect to the retardation mechanism, performance and ability to explain a variety of retardation phenomena. It is the authors' view that the Wheeler model can be conveniently used and the Matsuoka model has a clear physical meaning. Comments on the application of the retardation models in the estimation of the fatigue crack propagation life and the research on the retardation phenomena are also made.

**82-473**

**Statistical Treatment of Fatigue Test Data**

D.T. Raske

Argonne Natl. Lab., Argonne, IL, Rept. No. CONF-8009114-3, 27 pp (1980) (Presented at USDOE/UKAEA Specialist's Meeting on Mechanical Properties for FBR Materials, Warrington, UK, Sept 22, 1980)

DE81023924

**Key Words:** Fatigue tests, Statistical analysis

This report discussed several aspects of fatigue data analysis in order to provide a basis for the development of statistically sound design curves. Included is a discussion on the choice of the dependent variable, the assumptions associated with least squares regression models, the variability of fatigue data, the treatment of data from suspended tests and outlying observations, and various strain-life relations.

**82-474**

**High-Cycle Fatigue Behavior of Type 316 Stainless Steel at 593 exp 0 C**

D.T. Raske

Argonne Natl. Lab., Argonne, IL, Rept. No. CONF-8009114-4, 14 pp (1980) (Presented at USDOE/

UKAEA Specialists' Meeting on Mechanical Properties for FBR Materials, Warrington, UK, Sept 22, 1980)

DE81023925

**Key Words:** Fatigue life, Steel

The available low- and high-cycle fatigue data on Type 316 stainless steel at 593 to 600 exp 0 C have been combined and analyzed to provide a preliminary strain-life correlation. This correlation was then reduced by the appropriate safety factors to a design curve and compared with the ASME T-1420-1B curve. The comparison indicates that significant increases in allowable fatigue cycles should be realized when the present study is concluded.

**82-475**

**Statistical Reproducibility of the Dynamic and Static Fatigue Experiments**

J.E. Ritter, Jr. and K. Jakus

Dept. of Mech. Engrg., Massachusetts Univ., Amherst, MA, Rept. No. 1, 50 pp (Oct 1980)

AD-A100 469

**Key Words:** Ceramics, Fatigue life, Statistical analysis

The number of test samples used to characterize the fatigue constants needed for failure predictions for ceramic materials determines the confidence in these predictions. The statistical reproducibility of the dynamic and static fatigue experiments used to measure the fatigue constants was analyzed using both statistical theory and a Monte Carlo computer simulation technique. It was found that the statistical reproducibility depended not only on the number of test samples but also on the other experimental test variables.

**82-476**

**Cyclic Plasticity and Fatigue of Structural Components**

I. Kalev

Natl. Res. Council, NASA Dryden Flight Res. Ctr., Edwards, CA, J. Aircraft, 18 (10), pp 869-873 (Oct 1981) 8 figs, 20 refs

**Key Words:** Fatigue life, Prediction techniques, Crack propagation, Structural members

An analytical approach for low-cycle fatigue life prediction is presented. It accounts for both life to crack initiation and

crack growth rate due to cyclic plasticity. The approach combines a cyclic plasticity model with the finite-element method and damage accumulation criteria for ductile metals. The cyclic plasticity model is based on the concept of the combination of several yield surfaces. The surfaces are related to the material uniaxial stress-strain curve idealized by piecewise linear segments. The damage criterion for crack initiation is based on plastic strain Coffin-Manson formula modified for both mean stress variation effect and multi-axial varying stress-strain field. Crack growth retardation effects due to plasticity stress redistribution and compressive residual stresses are included. This approach requires testing data of only smooth specimens under constant strain amplitudes. Illustrative examples of a stiffened panel on an aircraft wing are presented.

**82-477**

**Fretting Fatigue Considerations in Engineering Design**

D.W. Hoepfner and F.L. Gates

Faculty of Applied Sci. and Engrg., Univ. of Toronto, Toronto M5S1A4, Canada, Wear, 70 (2), pp 155-164 (Aug 1, 1981) 3 figs, 1 table, 34 refs

**Key Words:** Fatigue life, Fretting corrosion

Fretting fatigue is becoming an increasingly recognized failure mechanism of engineering structures. In this paper the phenomenon of fretting fatigue, suggested mechanisms of fretting fatigue and experimental approaches to and methods of alleviation and prevention of fretting fatigue are discussed in concise form. Some general guidelines for design are presented, but the importance of dealing with each fretting fatigue situation is emphasized. The brief guidelines are presented, for additional insight, with reference to some of the current literature.

**82-478**

**Vibration Resistance under Multiaxial Excitation with and without Phase Shift (Schwingfestigkeit bei mehrachsiger Beanspruchung ohne und mit Phasenverschiebung)**

A. Troost and E. El-Magd

Inst. f. Werkstoffkunde der RWTH, Aachen, Germany, Konstruktion, 33 (8), pp 297-304 (Aug 1981)

16 figs, 16 refs

(In German)

**Key Words:** Fatigue life

Multiaxial excitation of isotropic and quasi-isotropic metals causes anisotropic fatigue. Taking this behavior into consid-

eration, fatigue conditions based on normal and shear stress, as well as on a general failure criterion, are derived. If the stress coordinates do not indicate any phase shift, then the examination of stress condition at a common point at the time of maximum deflection is sufficient. For excitations with phase shifts a time-dependent potential is determined, whose maximum and mean values are used to determine the danger of failure.

**82-479**

**Evaluation of the Effect of Geometrical Dimension by Means of Standardized Wöhler Line (Bewertung des geometrischen Grösseneinflusses mit dem Konzept der "Normierten Wöhlerlinie")**

W. Magin

Inst. f. Werkstoffkunde der TH Darmstadt, Germany, Konstruktion, 33 (8), pp 323-326 (Aug 1981) 4 figs, 1 table, 9 refs  
(In German)

**Key Words:** Fatigue tests

The results of a rotating flexural test, obtained by means of a uniform Wöhler scatter beam (normalized Wöhler line) with test samples ranging between 5.7 and 40.8 mm in diameter and at four stress concentration factors, are evaluated. It is shown that the series of experiments, regardless of the sample size, can be described very well by means of the normalized Wöhler line.

**82-480**

**Notched Fatigue and Fretting Fatigue Life of Textured Titanium**

A. Zarkades

Army Materials and Mechanics Res. Ctr., Watertown, MA, Rept. No. AMMRC-TR-81-22, 15 pp (May 1981) AD-A101 653

**Key Words:** Fatigue life, Fatigue (materials)

The effect of texture, poles in the transverse direction, on the notched and fretting fatigue life of a Ti-4Al-4V alloy was examined. Notched fatigue and pin-loaded flat fretting fatigue specimens were tested at room temperature in the longitudinal and transverse directions and compared to smooth bar fatigue results. Fractured fretting fatigue specimens were examined with the scanning electron microscope. Indications are that no fretting or notch fatigue anisotropy exists for the transverse type texture and specimen orientations examined. However, as expected, a significant reduc-

tion of the fatigue life is displayed for specimens subjected to fretting fatigue.

**82-481**

**The Effect of Tufftriding on the Rolling Contact Fatigue Behaviour of Low Alloy Steel Cylindrical Specimens**

C.S.N. Ram and A.R. Rao

Dept. of Mech. Engrg., Indian Inst. of Tech., Madras 600036, India, Wear, 70 (1), pp 53-62 (July 15, 1981) 10 figs, 3 tables, 8 refs

**Key Words:** Fatigue life, Fatigue (materials), Rolling friction, Strain hardening

Investigations of the rolling contact fatigue behavior of a low alloy steel are reported. Experiments were conducted on untreated and Tufftrided cylindrical specimens using Tellus 15 oil and contact stress-life curves were obtained. Both curves exhibit knee points with well-defined pitting limits. Tufftriding increases the pitting limit substantially. Wear loss studies indicated that Tufftriding leads to negligible wear loss under high contact stresses. Microhardness explorations established that strain hardening is exhibited by worked untreated specimens but no strain hardening was found with worked Tufftrided specimens. Tufftrided surfaces thus retain their original ductility and this contributes to their better performance under rolling contact fatigue conditions.

## EXPERIMENTATION

### MEASUREMENT AND ANALYSIS

**82-482**

**Modal Analysis of Non-Proportionally Damped Mechanical Structures**

H.N. Ozguven

Middle East Technical Univ., Turkey, ASME Paper No. 81-DET-75

**Key Words:** Damped structures, Layered damping, Modal analysis

A method for the modal analysis of a non-proportionally damped mechanical structure is suggested. The necessary

approximations and assumptions which allow the decoupling of the motion equations are discussed. The suggested approach finds a wide application field in the dynamic analysis of structures with constrained or unconstrained layer damping treatments.

**82-483**

**Windowed Sinusoidal Waveform Analysis Using the Short Time Averaged Cepstrum**

G. Koleyni

Ph.D. Thesis, Mississippi State Univ., 222 pp (1981)  
UM 8119205

**Key Words:** Cepstrum analysis, Elastic waves, Sound waves

Many signals of interest are composite waveforms which arise from multipath or multiple signal components. One particular class of signals consist of two separate components, an acoustic wave and a seismic wave, both generated from the same signal source. Use of multiple sensors, one acoustic and one seismic, can be used to receive these two signal components, which travel at different velocities, and to determine the difference in their times of arrival.

**82-484**

**Force Sensor-Machine Interaction**

R.A. Mitchell and P.E. Pontius

Natl. Bureau of Standards, Washington, DC, Final Rept., 8 pp (1981) (Presented at the Intl. Instrumentation Symp., April 27-30, 1981, Indianapolis, IN) PB81-221715

**Key Words:** Detectors, Force measurement, Error analysis

Although a force sensor is designed to respond primarily to an axial component of applied force, the sensor may also produce a significant error signal in response to non-axial load components that result from small misalignments in the loading setup. There may also be significant time-dependent machine-sensor-interaction errors involving creep or mechanical oscillation. This paper describes techniques that are being used to reveal, identify, and quantify these sources of error. The techniques involve the use of high-resolution readout instruments and a dedicated microcomputer/graphics system to make rapid comparisons of the response of force sensors to different loading conditions.

**82-485**

**Design and Analysis of a Torsion Braid Pendulum Displacement Transducer**

E. Rind and E.L. Bryant

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TP-1840, L-14183, 63 pp (June 1981)  
N81-25352

**Key Words:** Transducers, Measurement instruments, Vibration measurement, Torsional vibration

The dynamic properties at various temperatures of braids impregnated with polymer can be measured by using the braid as the suspension of a torsion pendulum. This report describes the electronic and mechanical design of a torsional braid pendulum displacement transducer which is an advance in the state of the art.

**82-486**

**A Single Element Cantilever Mounted Shear Wave Transducer**

B.A. Brunson

Dept. of the Navy, Washington, DC, PAT-APPL-6-272 591, 10 pp (July 11, 1981)

**Key Words:** Transducers, Measurement instruments, Shear waves

The present invention relates to a single element cantilever-mounted acoustic transducer for measuring shear wave attenuation in sediments. Such a transducer takes advantage of the transverse vibration of a piezoceramic bimorph element mounted as a cantilever on a heavy slug. A gasket material between the slug and an inner holding tube assists in avoiding the propagation of undesirable compressional wave energy into transmission medium surrounding the transducer.

**82-487**

**Errors Due to Finite Frequency Resolution in Digital Measurement of Frequency Responses**

H.R. Taylor

Dept. of Elect. Engrg. and Electronics, Univ. of Manchester, Inst. of Sci. and Tech., Sackville St., Manchester M60 1QD, UK, J. Phys. E: Sci. Instrum., 14 (9), pp 1088-1098 (Sept 1981)

**Key Words:** Measuring instruments, Vibration measurement, Frequency meters, Digital techniques, Error analysis, Computer programs

When a frequency response curve is represented by a limited number of points there may be an error in determining the peak value of the response. Considering the absolute, in-phase and quadrature responses of a single degree of freedom system, equations are derived and evaluated which relate the maximum error to the number of points within the 3 dB bandwidth.

#### 82-488

##### **Real-Time Vibration Rate Acquisition and Signal Processing Using a Low-Cost Microcomputer**

M.S. Darlow and D.L. Goodman

Univ. of Florida, Gainesville, FL, ASME Paper No. 81-DET-28

**Key Words:** Vibration meters, Measuring instruments, Real time spectrum analyzers, Central processing units, Computer-aided techniques

*This paper describes a real-time vibration data acquisition and signal processing system which has been configured using a low-cost microcomputer. In addition to being relatively inexpensive to assemble, this system is also very versatile. The principal hardware and software components of this system are described along with a number of possible applications.*

#### 82-489

##### **In-Service Measurements of Turbogenerator Bearing Vertical Misalignments**

G.L. Lapini, T. Rossini, E. Gadda, and A. Bernanti  
Centro Informazioni Studi Esperienze, Milan, Italy,  
Rept. No. CISE-1631, 13 pp (1980) (Presented at  
Epri Workshop on Rotor Forging for Turbines and  
Generators, Asilomar Conf. Site, CA, Sept 15-17,  
1980)

N81-24456

**Key Words:** Measuring instruments, Alignment, Bearings, Turbogenerators

Two instruments were developed which measure long-term trends in alignment variations. The catenary measuring instrument which works on the communicating vessel principle, is used in spot measurements and has a maximum measuring error of 0.02 mm. The electronic differential altimeter also works on the communicating vessel principle, but liquid

levels are converted into continuous voltage variations by proximity transducers fixed to the cup tops. A voltage proportional to the relative displacement of the measuring cup, and for the reference cup, is obtained. Temperature and pressure equalization are described. Examples of applications are presented.

#### 82-490

##### **The Measurement of Dynamic Normal and Frictional Contact Forces During Sliding**

A. Soom and C.-H. Kim

State Univ. of New York at Buffalo, NY, ASME Paper No. 81-DET-40

**Key Words:** Coulomb friction, Measurement techniques

Dynamic normal and frictional forces, including inertia forces, were measured at frequencies between 0 and 2 kHz during the nominally smooth sliding of unlubricated steel surfaces using a pin-on-disc type apparatus. It was found that large audio-frequency normal and frictional force fluctuations are present, long before significant loss of contact or other obvious changes in frictional force behavior begin to occur.

#### 82-491

##### **Digital Spectral Analysis: A Guide Based on Experience with Aircraft Vibrations**

S.L. Buckingham

Royal Aircraft Establishment, Farnborough, UK,  
Rept. No. RAE-TR-81014, 59 pp (Feb 1981)  
DRIC-BR-78387

**Key Words:** Spectrum analysis, Digital techniques, Aircraft vibration, Flight tests

A guide to digital spectral analysis is presented. The emphasis is on a practical engineering understanding of the techniques, based on experience gained in their application to the analysis of flight measurements of aircraft vibration in buffet. Consequently, particular attention is directed to the practical difficulties encountered when the duration of the available data is severely limited, and to the use of the coherence function as a tool in the interpretation of complicated responses. However, the presentation of the fundamental principles, and especially the inherent limitations of the techniques are relevant to any sphere of application.

## **DYNAMIC TESTS**

(Also see Nos. 302, 334, 339)

**82-492**

### **Automating Shock Testing with Desk Top Computers**

R.G. Widdifield

Naval Undersea Warfare Engrg. Station, Keyport, WA,  
Test, 43 (5), pp 8, 9, 14 (Oct/Nov 1981)

**Key Words:** Test equipment and instrumentation, Shock tests, Underwater structures, Weapons systems

A system for testing underwater weapons is described. The system provides a frequency analysis of the shock, and annotates the resultant plot with such data as the test date, ID number, and test axis. Data are recorded on cassette tapes so that further analysis is possible, such as velocity-change determination.

**82-493**

### **Sandia 25-Meter Compressed Helium/Air Gun**

R.E. Setchell

Sandia Natl. Labs., Albuquerque, NM, Rept. No. SAND-81-1477C, CONF-810684-2, 4 pp (1981)  
(Presented at APS Conference on Shock Waves in Condensed Matter, Menlo Park, CA, June 23, 1981)  
DE81024068

**Key Words:** Shock tests, Test facilities

For nearly twenty years the Sandia 25-m compressed gas gun has been an important tool for studying condensed materials subjected to transient shock compression. Major system modifications are now in progress to provide new control, instrumentation, and data acquisition capabilities. These features will ensure that the facility can continue as an effective means of investigating a variety of physical and chemical processes in shock-compressed solids.

**82-494**

### **Sandia Shock Thermodynamics Applied Research Facility**

L.C. Chhabildas

Sandia Natl. Labs., Albuquerque, NM, Rept. No. SAND-81-1528C, CONF-810684-1, 5 pp (1981)  
(Presented at APS Conference on Shock Waves in

Condensed Matter, Menlo Park, CA, June 23, 1981)  
DE81024066

**Key Words:** Shock tests, Test facilities

A brief description of the Sandia Shock Thermodynamics Applied Research Facility is given. Three different smooth-bore guns are used to launch projectiles for controlled planar impact studies. Combined pressure-shear loading conditions can also be obtained through use of an intervening anisotropic crystal. Time-resolved interferometric and holographic instrumentation is used for diagnostics. This facility has the unique capability of providing time-resolved measurements in shock loaded specimens over the stress range 0.1 to 700 GPa.

**82-495**

### **Vibration Test Criteria for Aircraft Equipment**

P.S. Hall

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, Rept. No. AFWAL-TR-80-3119, 30 pp (Dec 1980)  
AD-A098 675

**Key Words:** Aircraft equipment response, Vibration tests, Testing techniques

This study details inhouse efforts that recommend vibration test level criteria for reliability of aircraft equipment. The study assesses the impact of current vibration test level criteria on the resultant reliability statistics of aircraft equipment. Problems of profiling mission vibration environmental stresses as compared to other environmental stresses are analyzed. An analysis of the readily available tools to determine the vibration stresses is also conducted. A comparison is made of various vibration exposure times and levels for a number of equipment under multiple tests. The resulting reliability under the multiple tests is compared to field reliability data for the equipment studied.

**82-496**

### **Design and Analysis of a Seismically Stable Platform. An Evaluation**

M.G. Jaenke

Armament Div. (AFSC), Elgin AFB, F, Rept. No. AD-TR-80-74, 55 pp (Aug 1980)  
AD-A096 530

**Key Words:** Seismic design, Testing techniques, Dynamic tests

This paper analyzes a Technical Report (TR 7015.003) furnished to the 6585th Test Group by Measurement Analysis Corporation, in support of the Seismically Stable Platform project. There are six major conclusions: the proposed passive system is basically sound. An active system should improve transmissibility over the estimates given in the MAC report; platform rocking modes may be induced by purely translational ground motion; apparent platform rocking would be seen by mismatched seismometer pairs. It is not clear that seismometers can be matched to monitor small rotations; the 6585th Test Group should further characterize the rotational and translational motions of the test site; in the future, test analysts should be able to separate test item errors from platform-induced motions. By monitoring known events such as airplane overflights and sled runs, the analyst can account for much of the induced vibration; and by band-selectable analysis, the analyst can disregard much of the input vibration.

**82-497**

**Feasibility of Dynamic Testing of As-Built Nuclear Power Plant Structures: An Interim Evaluation**  
M.G. Srinivasan, C.A. Kot, B.J. Hsieh, and H.H. Chung

Argonne Natl. Lab., Argonne, IL, Rept. No. ANL-CT-81-5, 55 pp (May 1981)  
NUREG/CR-1937

**Key Words:** Dynamic tests, Testing techniques, Nuclear power plants, Power plants (facilities)

Goals of dynamic tests, excitation techniques, excitation levels, instrumentation, data acquisition, data analysis, determination of dynamic characteristics from test data, and post-test analytical modeling including different parameter identification approaches are discussed. Dynamic testing is found to be feasible, and low-level testing is deemed to be useful for verifying analytical models used in design practice. Proof testing at design-level excitation is considered impractical, and only a combined low-level testing cum analytical modeling approach is considered to be the means for predicting response to high-level excitations. The need for better analytical methodologies calls for further effort before testing can become part of the normal licensing process.

**82-498**

**Effect of Vibrations on the Density of Loose-Fill Insulations**

D.W. Yarbrough and J.H. Wright  
Dept. of Chemical Engrg., Tennessee Technological

Univ., Cookeville, TN, 36 pp (May 1981)  
ORNL/Sub-7715

**Key Words:** Drop tests (impact tests), Vibration tests, Insulation, Density (mass/volume)

Testing results of the three major loose-fill insulation products marketed in this country subjected to a variety of vibrations and impacts in a laboratory setting to determine the magnitude of the resultant density increases, are presented.

**82-499**

**Electron-acoustic Microscopy**

G.S. Cargill, III  
Cavendish Lab., Univ. of Cambridge, UK, Physics  
Today, pp 27-32 (Oct 1981) 6 figs, 1 table, 18 refs

**Key Words:** Testing techniques, Nondestructive tests, Acoustic tests

Electron-acoustic microscopy is a new technique enabling us to produce images that show variations in an object's thermal and elastic properties with a resolution on the order of microns. These images appear dramatically different than optical or electron microscope pictures, and contain much information not otherwise available.

**82-500**

**Nondestructive Testing in the 80's**

H. Berger  
Natl. Bureau of Standards, Washington, DC, Final  
Rept., 5 pp (Apr 1981)  
PB81-220428

**Key Words:** Nondestructive tests

Present methods for nondestructive testing are reviewed briefly. The main emphasis in the paper is a look ahead toward the use of NDT in the immediate future. Increased use is seen for computer technology and signal processing, for the nondestructive characterization of both defects and material parameters, for traceable NDT measurements and continuous monitoring of machinery, engines and structures. Examples of NDT developments are given to support these predictions.

## SCALING AND MODELING

82-501

### Theory and Application of Experimental Model Analysis in Earthquake Engineering

P.D. Moncarz

Ph.D. Thesis, Stanford Univ., 279 pp (1981)

UM 8124110

**Key Words:** Seismic design, Test models

This report summarizes part of a four year study on the feasibility and limitations of small-scale model studies in earthquake engineering research and practice. The emphasis is placed on dynamic modeling theory, a study of the mechanical properties of model materials, the development of suitable model construction techniques and an evaluation of the accuracy of prototype response prediction through model case studies on components and simple structures. Steel and reinforced concrete structures are considered in this study.

## DIAGNOSTICS

82-502

### Analyzing Turbomachinery Problems: Sometimes a Signature is Not Enough

G. Muller

Exxon Res. and Engrg. Co., Florham Park, NJ, InTech., 28 (10), pp 53-56 (Oct 1981)

**Key Words:** Diagnostic techniques, Machinery

Conditions warranting machinery shutdown typically become evident from vibration measurements, noise, or other abnormal operating characteristics. Because of the risks and costs associated with the shutdown decision, however, more conclusive information is often needed to ensure that neither safety nor profitability is being compromised. Spectral analyzers have become essential in evaluating these problems, but definitive recommendations for action often require additional information, such as operating, maintenance, and thermodynamic performance data. The use of spectral analyzers and the need for auxiliary data in diagnosing complex machinery is illustrated by three compressor train problems.

82-503

### The Utilization of Signal Processing and Pattern

### Recognition for the Advancement of Ultrasonic Nondestructive Testing

M.J. Avioli

Ph.D. Thesis, Drexel Univ., 155 pp (1981)

UM 8118925

**Key Words:** Diagnostic techniques, Failure detection, Signal processing techniques, Pattern recognition techniques, Ultrasonic techniques, Nondestructive tests

Until recently, ultrasonic inspection has relied upon some very basic concepts, making use of, for example, a pulser unit, a piezoelectric transducer, and an oscilloscope display. The thesis consists of two major parts, the first describes the availability of suitable tools for analysis, and the second in describing two sample problems that can be handled with this integrated technology.

82-504

### A Case Study of the Use of Experimental Modal Analysis as a Problem Solving Technique

L.W. Tweed

Flat-Allis CMI, Springfield, IL, ASME Paper No. 81-DET-31

**Key Words:** Diagnostic techniques, Modal analysis, Fatigue life, Heat radiators

This paper describes the use of experimental modal analysis to pinpoint the cause of a fatigue failure of a prototype radiator for a Fiat-Allis wheel loader. This analysis was performed with the radiator in a machine to ensure that end constraints would be properly modeled. Several radiator core modes found are described.

82-505

### Acoustic Spectrometry as Used for the Evaluation of Tribological Systems

V.A. Belyi, O.V. Kholodilov, and A.I. Sviridyonok  
Inst. of Mech. of Metal-Polymer-Systems, Academy of Sciences of the Belorussian S.S.R., Gomel, USSR, Wear, 69 (3), pp 309-319 (July 1, 1981) 6 figs, 1 table, 31 refs

**Key Words:** Diagnostic techniques, Acoustic emission, Spectrum analysis, Wear, Friction

A study is presented of tribological metal-polymer systems. Parameter analysis by acoustic emission resulting from ex-

ternal friction was used. The experimental results obtained for metal-polymer friction pairs are dependent on various factors including load, velocity of relative travel, microgeometry of the contacting surfaces, physicomachanical properties of the materials and testing period. The rates of acoustic emission, the total acoustic emission and the magnitude of the frequency emission spectrum were used as informative characteristics concerning friction and wear kinetics. A number of general relations were determined for friction pairs, reflecting the influence of these factors on the acoustic activity of a rubbing contact.

## BALANCING

82-506

### The Equipment for Dynamic Balancing of Grinding Wheels (Einrichtungen zum dynamischen Auswuchten von Schleifscheiben)

V.J. Wojtowicz and C. Keller

Inst. f. Spangebende Bearbeitung, Cracow, Poland,  
VDI Z., 14, pp 19-20 (July 1981) 2 figs  
(In German)

Key Words: Dynamic balancing, Balancing machines

Equipment for the dynamic balancing of grinding wheels is described which reduces the balancing time by a factor of fifteen and helps to maintain very small tolerances.

## MONITORING

82-507

### Vibration Monitoring and Analysis

J.I. Taylor

Vibration Consultants, Inc., Tampa, FL, Plant Engrg.,  
35 (21), pp 127-130 (Oct 15, 1981) 5 figs

Key Words: Vibration monitoring, Rotating machinery

Three distinct areas of the maintenance program for rotating equipment are quality assurance of spare components used in repairs, ultrasonic testing of pipes and vessels, and vibration monitoring and signature analysis of on-line machines. The cornerstone of such program is vibration, monitoring and analysis which is discussed in the article.

82-508

### Sensing Shaft Rotating with Proximity Switches

G.T. Noble

Namco Controls, Mentor, OH, Power Transm. Des.,  
pp 62-63 (Oct 1981)

Key Words: Monitoring techniques, Proximity probes, Shafts

The use of radio frequency proximity switches in shaft-speed sensing applications is described. These versatile non-contact electronic devices provide the means for quick and accurate detection of an under or overspeed condition, enabling the prevention of motor burnout or the failure of a conveyor belt.

82-509

### Enhanced Reliability and Reproducibility of Measurements of Machinery Vibrations

L. Mordfin, B.F. Payne, and S. Edelman

Natl. Bureau of Standards, Washington, DC, Final Rept., 22 pp (Sept 1980)  
PB81-220410

Key Words: Vibration monitoring, Machinery vibration, Calibrating, Vibration probes, Displacement measurement

Using vibration measurements to monitor the condition of machinery and machine elements offers several advantages over traditional methods of nondestructive evaluation. This paper reviews some of the activities being carried out at the U.S. National Bureau of Standards (NBS) in support of this rapidly advancing measurement technology.

82-510

### Failure-Cause Analysis: Turbine Bearing Systems. Phase I. Development of Data Collection Plan

H.C. Rippel

Franklin Res. Ctr., Philadelphia, PA, 28 pp (Apr 1981)  
EPR1-CS-1801-SY

Key Words: Monitoring techniques, Failure analysis, Data processing, Turbines, Bearings

This report comprises the summary of the first of a three phase study intended to investigate rotor/bearing/lube system-related failures in large capacity (greater than or equal to 300 MW) turbine/generator units. The objectives of Phase I were to identify and tentatively rank the proximate/root causes of generic problems that result in failures

of the rotor/bearing/lube system; determine the nature of the available data and select the appropriate methodologies for both data collection and analysis; and develop the data collection and analysis; and develop the data collection plan to be implemented during Phase II.

**82-511**

**The Monitoring of Machines (Surveillance des Machines)**

M. Gaillochet

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-15-J-041-PT-2, 44 pp (Aug 1980)

N81-24480

(In French)

**Key Words:** Monitoring techniques, Machinery, Computer-aided techniques, Gears

The application of classical vibration analysis to the surveillance of the mechanical condition of machines is described. Automated procedures handled by specialized computers, using advanced signal processing techniques, are sought. Vibration measurement and analysis are reviewed, covering sensors and recorders, frequency analyzers, and methods for visualizing results. Existing procedures for monitoring machine wear are touched on. A method for determining vibration signatures is proposed.

**82-512**

**The Monitoring of Machines. Preliminary Study of a Transmission (Surveillance des Machines. Etude Preliminaire sur Une Boite de Vitesse)**

G. Garcin

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-15-J-041-PT-3, 15 pp (Sept 1980)

N81-24481

(In French)

**Key Words:** Monitoring techniques, Transmission systems, Power transmission systems, Automotive transmissions

The application of vibration analysis to the surveillance of the mechanical condition of machines is proposed. A signal processing method, given vibration measurement data, is suggested. This method was validated, using a wear test setup for studying the behavior of an automobile transmission to failure. The test bench is described, including type

and frequency of measurements as well as measurement methodology. Results demonstrate the feasibility of diagnosing wear on machine parts through the statistical analysis of associated vibration signatures.

**82-513**

**Investigation into Continuous Acoustic Emission Monitoring of BWR Components. Semi-Annual Report**

J.W. McElroy

Philadelphia Electric Co., PA, 81 pp (June 2, 1980)  
DOE/ET/34216-T2

**Key Words:** Nuclear reactors, Nuclear reactor components, Monitoring techniques, Acoustic emission

This report covers the work on continuous acoustic emission monitoring of BWR components. It was found that coupling efficiency and the sensitivity of the sensors did not vary significantly with time. Correlation between AE results and the results from alternate inservice inspection techniques has been initiated.

## ANALYSIS AND DESIGN

### ANALOGS AND ANALOG COMPUTATION

**82-514**

**Linear Prediction Theory for Digital Simulation of Sea Waves**

P.T.D. Spanos and J.E. Hansen

The Univ. of Texas at Austin, Austin, TX, J. Energy Resources Tech., Trans. ASME, 103 (3), pp 243-249 (Sept 1981) 9 figs, 2 tables, 16 refs

**Key Words:** Hydrodynamic excitation, Water waves, Simulation

Most of the currently used algorithms for numerical generation of sea wave records which are compatible with a specified power spectrum are based on the superposition of several harmonic waves. This article presents an alternative method of simulation. The basis of the method is the linear prediction theory which has been extensively used in processing digital data in other technical fields. Specifically,

records of sea waves which are compatible with the target spectrum are obtained as the output of a recursive digital filter to a white noise input. A procedure for determining the filter parameters is discussed. Several numerical examples are presented.

## ANALYTICAL METHODS

(Also see No. 259)

82-515

**Limits of Application of Specific Combined Laws of Motion to Cams (Anwendungsgrenzen spezieller kombinierter Bewegungsgesetze bei Kurvengetrieben)**  
G. Dittrich and H.W. Leyendecker  
Inst. f. Getriebetechnik und Maschinendynamik der RWTH, Aachen, Germany, *Konstruktion*, **33** (9), pp 337-340 (Sept 1981) 7 figs, 1 ref  
(In German)

**Key Words:** Standards and codes, Cams

Several problems are investigated which arise during the numerical determination of critical parameters for cams when using the German Standard VDI 2143 for specific combined laws of motion. Limits for the possible combinations of boundary conditions for the equations in question are presented.

82-516

**Time and Frequency Domain Analysis of Sampled Data Controllers via Mixed Operation Equations**  
H.P. Frisch  
NASA Goddard Space Flight Center, Greenbelt, MD, Rept. No. NASA-TP-1817, 25 pp (June 1981)  
N81-25139

**Key Words:** Time domain method, Frequency domain method

Specification of the mathematical equations required to define the dynamic response of a linear continuous plant, subject to sampled data control, is complicated by the fact that the digital components of the control system cannot be modeled via linear ordinary differential equations. This complication can be overcome by introducing two new mathematical operations; namely, the operation of zero order hold and digital delay.

82-517

## **A Response Spectrum Method for Random Vibration Analysis of MDF Systems**

A. Der Kiureghian

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, *Earthquake Engrg. Struc. Dynam.*, **9** (5), pp 419-435 (Sept-Oct 1981) 10 figs, 1 table, 19 refs

**Key Words:** Random vibration, Response spectra, Multi-degree of freedom systems, Seismic response

A response spectrum method for stationary random vibration analysis of linear, multi-degree-of-freedom systems is developed. The method is based on the assumption that the input excitation is a wide-band, stationary Gaussian process and the response is stationary. Various response quantities, including the mean-squares of the response and its time derivative, the response mean frequency, and the cumulative distribution and the mean and variance of the peak response are obtained in terms of the ordinates of the mean response spectrum of the input excitation and the modal properties of the system. The formulation includes the cross-correlation between modal responses, which is shown to be significant for modes with closely spaced natural frequencies. The proposed procedure is demonstrated for an example structure that is subjected to an ensemble of earthquake-induced base excitations. Computed results based on the response spectrum method are in close agreement with simulation results obtained from time-history dynamic analysis. The significance of closely spaced modes and the error associated with a conventional method that neglects the modal correlations are also demonstrated.

82-518

## **Vibrations of Locally Modified Mechanical and Structural Systems**

A.B. Palazzolo

Ph.D. Thesis, Univ. of Virginia, 308 pp (1981)  
UM 8117919

**Key Words:** Optimum design, Damped structures, Eigenvalue problems, Active vibration control, Vibration control, Parameter identification technique

This dissertation develops several new, approximate reanalysis procedures for solving the free and harmonically forced response problems of damped, unsymmetric systems. By fully exploiting the sparsity of the modifications to these systems, the procedures are computationally efficient. The modified systems are condensed by employing generalized receptance matrix elements. An improved hybrid spectral-property matrix receptance formalism is derived. This formalism is applicable to the general, unsymmetric, quadratic eigenvalue problem. The dissertation also develops algorithms

for eigensolution component synthesis, eigenvalue design and forced harmonic response design. The results of the dissertation demonstrate that by applying the reanalysis and design schemes to the search for an optimized structural design, the computational efficiency may be substantially increased over standard exact solution techniques.

**82-519**

**Application of the Generalized Eigenstructure Problem to Multivariable Systems and the Robust Servomechanism for a Plant which Contains an Implicit Internal Model**

A. Emami-Naeini

Ph.D. Thesis, Stanford Univ., 251 pp (1981)  
UM 8124058

**Key Words:** Structural synthesis, Dynamic systems

In this thesis some structural properties as well as design and synthesis techniques for linear time-invariant finite-dimensional multivariable dynamic systems are studied. Some generalizations of the well established concepts of classical control theory which deals with scalar systems are investigated. The emphasis of the study has been on development of new numerically stable algorithms for the design of multivariable systems using the state-space techniques. The first four topics under consideration possess a common generalized eigenstructure formulation and can be studied in terms of matrix pencils. The other topics are concerned with the multi-variable robust servomechanism problem which is a generalization of the classical integral control.

## MODELING TECHNIQUES

(Also see No. 534)

**82-520**

**Basic Course in Finite-Element Analysis - Basic Concepts**

N. Rieger and J.M. Steele

Stress Technology Inc., Rochester, NY, Machine Des., 53 (15), pp 103-107 (June 25, 1981)

**Key Words:** Finite element technique, Reviews

This article is the first of a three part series on the finite element theory. It shows how to derive the arrays of large matrix of stiffness and deflection equations and how to apply them.

**82-521**

**Basic Course in Finite-Element Analysis - Modeling**

N.F. Rieger and J.M. Steele

Stress Technology Inc., Rochester, NY, Machine Des., 53 (16), pp 153-157 (July 9, 1981)

**Key Words:** Finite element technique, Reviews

This second installment of a three part series on finite element technique discusses some general modeling guidelines and describes a number of techniques that can be used to ensure the construction of an accurate model.

**82-522**

**An Assumed Hybrid Displacement Finite Element Model for Elastodynamic Cracked Problems**

W.-H. Chen and C.-H. Wang

Dept. of Power Mech. Engrg., Natl. Tsing Hua Univ., Hsinchu, Taiwan, 300, Republic of China, Engrg. Struc., 3 (4), pp 249-255 (Oct 1981) 8 figs, 18 refs

**Key Words:** Finite element technique, Cracked media, Elastodynamic response

This paper presents an assumed hybrid displacement finite element model to deal with elastodynamic crack problems. Based on a modified Hamilton's principle with relaxed continuity requirements for displacements at the inter-element boundary, the mass and stiffness matrix of singular elements embedded with proper singularity near the crack-tip are derived. Good correlations between the computed results and the referenced data can be drawn.

**82-523**

**Modelling of Soil-Structure Interaction by Finite and Infinite Elements**

F. Medina

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-80/43, NSF/RA-800548, 68 pp (Dec 1980)  
PB81-229270

**Key Words:** Interaction: soil-structure, Finite element technique, Infinite element technique, Mathematical models

A direct method for solving dynamically excited structures on elastic semi-infinite media is suggested as an improvement over available approaches. The method consists in modeling the near field with finite elements and the far field with

infinite elements. The method falls within the framework of the classical finite element method and preserves its flexibilities.

**82-524**

**A Modeling Technique for Subsonic Stall Flutter in Cascades**

J.F. Sparks

Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 123 pp (1981)

UM 8118715

**Key Words:** Mathematical models, Flutter, Cascades, Blades, Torsional vibration

By combining a dynamic stall model with the equations of motion for a two-dimensional cascade of blades, a model was created which simulated torsional self-excited vibration of the cascade blades. The dynamic stall model was developed from isolated airfoil data found in the literature. The lift and moment coefficients were correlated in Fourier magnitude and phase form with the reduced frequency, mean incidence angle, and the magnitude of the incidence angle change during the airfoil oscillation at a given Mach number.

**82-525**

**Analytical Consideration of Fuel Economy and Dynamic Response of a Regenerative High Temperature Automobile Gas Turbine - Part II**

T. Takeuchi, T. Itoh, and T. Ishida

Nissan Motor Co., Ltd., Japan, ASME Paper No. 81-GT-218

**Key Words:** Automobile engines, Dynamic response, Mathematical models, Computer-aided techniques

In order to further study the characteristics of the ceramic gas turbine, a mathematical model for a gas turbine vehicle system was constructed on a hybrid computer, and the dynamic characteristics of a two-shaft regenerative gas turbine were calculated. Also calculated was the 10-mode fuel economy for various control systems.

**82-526**

**Stable Linear Systems Simplification via Padé Approximations to Hurwitz Polynomials**

Y. Bistritz and U. Shaked

School of Engrg., Tel Aviv Univ., Tel Aviv, Israel, J. Dyn. Syst., Meas. and Control, Trans. ASME, 103 (3), pp 279-284 (Sept 1981) 1 fig, 3 tables, 21 refs

**Key Words:** Mathematical models

In many problems of control and simulation of a high order system, it is often advantageous to have an appropriate lower order model for approximate design. Introducing the concept of (mixed) Padé approximations to Hurwitz polynomials, a novel method for linear time invariant system simplification is established. The method offers many models of the same order that are stable for a stable system, approximate a desired number of the system eigenvalues near to and far from the origin, and emphasize differently the approximation of the low frequency/steady-state and high frequency/transient responses of the system. The presented method is based entirely on a simple unified Padé technique.

## NONLINEAR ANALYSIS

**82-527**

**Vibration of Skeletal Structures - An Overview**

B.Å. Åkesson

Div. of Solid Mechanics, Chalmers Univ. of Tech., Gothenburg, Sweden, Chalmers Tekniska Högskola, Hållfasthetslära, Skrift F66, 40 pp, 18 figs, 29 refs, Proc. of 1st Theoretical and Applied Mechanics Conference, Cairo, Egypt, Dec 16-19, 1980, sponsored by Egyptian National Committee of Theoretical and Applied Mechanics

**Key Words:** Vibration analysis, Numerical methods, Reviews

This overview has been written both to promote teaching and research in the theory of vibrations and to encourage development and implementation of numerical methods for application of this theory to practical engineering problems.

## NUMERICAL METHODS

**82-528**

**Evaluation of Eigenvalues in Regions of Complicated Boundary Shape in Problems Governed by Helmholtz Equation**

G.S. Sarmiento, P.A.A. Laure, and R.H. Gutierrez

Comision Nacional de Energia Atómica, Argentina,  
ASME Paper No. 81-DET-76

**Key Words:** Eigenvalue problems, Boundary condition effects, Conformal mapping, Variational methods, Finite element technique

This paper presents some numerical experiments on the determination of fundamental eigenvalues when Dirichlet or Neumann's boundary conditions are prescribed. Results are obtained by a conformal mapping-variational approach, and also by a finite element program.

**82-529**

**Pitfalls and Guidelines for the Numerical Evaluation of Moderate-Order System Frequency Response**  
H.P. Frisch

NASA Goddard Space Flight Ctr., Greenbelt, MD,  
Rept. No. NASA-TP-1814, 36 pp (June 1981)  
N81-25138

**Key Words:** Numerical analysis, Frequency response

The design and evaluation of a feedback control system via frequency response methods relies heavily upon numerical methods. In application, one can usually develop low order simulation models which for the most part are devoid of numerical problems. However, when complex feedback interactions, for example, between instrument control systems and their flexible mounting structure, must be evaluated, simulation models become moderate to large order and numerical problems become common. A large body of relevant numerical error analysis literature is summarized in a large language understandable to nonspecialists. The intent is to provide engineers using simulation models with an engineering feel for potential numerical problems without getting intertwined in the complexities of the associated mathematical theory. Guidelines are also provided by suggesting alternate state of the art methods which have good numerical evaluation characteristics.

**82-530**

**Analysis of Vibration by Component Mode Synthesis Method (Part 1. Natural Frequency and Natural Mode, (I) )**

A. Nagamatsu and M. Ookuma  
Industrial Faculty, Tokyo Inst. of Tech., Meguroku,  
Tokyo, Japan, Bull. JSME, 24 (194), pp 1448-1453  
(Aug 1981) 9 figs, 4 tables, 8 refs

**Key Words:** Vibration analysis, Component mode synthesis, Natural frequencies, Mode shapes, Finite element technique, Plates, Rectangular plates

A method is presented to analyze the vibration of a complex mechanical structure by using the natural modes of the components. A structure is divided into some components. All components are classified into master components and branch components. The natural modes of each component are determined separately by the finite element method. The natural modes of all components are synthesized to form the generalized system coordinates.

## STATISTICAL METHODS

(See Nos. 272, 475)

## PARAMETER IDENTIFICATION

(Also see Nos. 319, 535)

**82-531**

**The Theory and Practice of Estimating the Accuracy of Dynamic Flight-Determined Coefficients**

R.E. Maine and K.W. Iliff

NASA Dryden Flight Res. Ctr., Edwards, CA, Rept.  
No. NASA-RP-1077, H-1128, 63 pp (July 1981)  
N81-27865

**Key Words:** Parameter identification technique, Flight test data, Aircraft

Means of assessing the accuracy of maximum likelihood parameter estimates obtained from dynamic flight data are discussed. The most commonly used analytical predictors of accuracy are derived and compared from both statistical and simplified geometrics standpoints. The accuracy predictions are evaluated with real and simulated data, with an emphasis on practical considerations, such as modeling error.

**82-532**

**Model Order and Parameter Identification from Layered Media Response Data**

J.N. Holyoak

Ph.D. Thesis, Texas A&M Univ., 198 pp (1981)  
UM 8118270

**Key Words:** Parameter identification technique, Layered materials

This dissertation investigates the generation of a maximum likelihood estimation algorithm for the simultaneous solution of the order and the reflection coefficients of a reverberative, non-absorptive, horizontally stratified, layered media. The approach taken involves utilizing response data from both the input excitation as well as the response data from the layered media to form estimates of a composite model which includes the excitation model and the layered media model.

## OPTIMIZATION TECHNIQUES

82-533

### **Vincent's Circle as a Tool for Machine Vibration Optimization Techniques**

E.J. Nagy

Kaman Aerospace Corp., Bloomfield, CT, ASME Paper No. 81-DET-78

**Key Words:** Machinery vibration, Vincent Circle method, Point source excitation, Optimization

An analytical approach for evaluating proposed changes to a machine with vibration problems is presented.

## COMPUTER PROGRAMS

(Also see No. 259)

82-534

### **Software for Structural Analysis**

J.K. Krouse

Mach. Des., 53 (23), pp 151-156 (Oct 8, 1981)

**Key Words:** Computer programs, Finite element technique

A brief review of finite element analysis programs is presented beginning with their development in mid 1960s through today's finite element software applicable to simple beam deflections as well as complex machine dynamics.

82-535

### **Programmer's Manual for MMLE3, a General Fortran Program for Maximum Likelihood Parameter Estimation**

R.E. Maine

NASA, Hugh L. Dryden Flight Res. Ctr., Edwards, CA, Rept. No. NASA-TP-1690, H-1105, 118 pp (June 1981)

N81-27813

**Key Words:** Computer programs, Parameter identification technique, Aircraft

The MMLE3 is a maximum likelihood parameter estimation program capable of handling general bilinear dynamic equations of arbitrary order with measurement noise and/or state noise (process noise). The basic MMLE3 program is quite general and, therefore, applicable to a wide variety of problems. Complete listings and reference maps of the routines are included on microfiche as a supplement. Four test cases are discussed; listings of the input cards and program output for the test cases are included on microfiche as a supplement.

82-536

### **Computer Implementation of Optimal Multivariable Controller Design in the Frequency Domain**

J.E. Perrault

Ph.D. Thesis, Oklahoma State Univ., 129 pp (1981) UM 8123850

**Key Words:** Optimization, Control equipment, Frequency domain method, Computer programs

Problems associated with the numerical computation of optimal controllers using frequency domain synthesis theory are investigated. A suitable synthesis theory is identified and a generalized computational method for obtaining necessary transfer function matrices directly from block diagrams is developed. The logical structure of a computer program for optimal controller design is presented.

82-537

### **STINT/CD: A Stand-Alone Explicit Time Integration Package for Structural Dynamics Analysis**

P. Underwood and K.C. Park

Applied Mechanics Lab., Lockheed Palo Alto Res. Lab., Palo Alto, CA, Intl. J. Numer. Anal. Methods Engrg., 17 (9), pp 1285-1312 (Sept 1981) 8 figs, 1 table, 6 refs

**Key Words:** Computer programs, Equations of motion, Transient response, Time-dependent parameters

This paper is a user's guide for the stand-alone explicit direct time integration package STINT/CD for structural dynamics analysis. STINT/CD uses an automatic variable time increment central difference method. The purpose, function, limitations and usage of the package are described. A FORTRAN listing of STINT/CD is given along with a sample problem which illustrates its usage and performance.

**82-538**

**Shockless Design and Analysis of Transonic Blade Shapes**

D.S. Dulikravich and H. Sobieczky

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-82611, E-861, 13 pp (1981) (Presented at the 14th Fluid and Plasma Dyn. Conf., Palo Alto, CA, June 23-25, 1981; Sponsored by the American Inst. of Aeronautics and Astronautics) N81-25036

**Key Words:** Computer programs, Design techniques, Computer-aided techniques, Blades, Airfoils

A fast computer program was developed to eliminate the shocks by slightly altering portions of the contour of a given airfoil in the cascade. The program can be used in two basic modes: an analysis for steady, transonic, potential flow through a given planar cascade of airfoils; and a design for converting a given cascade into a shockless transonic cascade. The design mode can automatically be followed by the analysis mode, which confirms that the flow field is shock free. The program generates its own multilevel boundary conforming computational grids and solves a full potential equation in a fully conservative form. The shockless design is performed by implementing Sobieczky's fictitious-gas elliptic continuation concept.

**82-539**

**Rotor-Bearing Dynamics Technology Design Guide. Part IX. User's Manual**

D.S. Wilson and C.H.T. Pan

Shaker Research Corp., Ballston Lake, NY, Rept. No. SRC-80-TR-58, AFAPL-TR-78-6-PT-9, 249 pp (Apr 1981) AD-A100 210

**Key Words:** Computer programs, Rotors

RSVP (acronym) for Rotor Structure Vibration Program is a computer program for use in the dynamic analysis of

rotating shafts. This manual outlines the procedures to be followed in utilizing the computer program, covering input and output description and includes two rotor examples covering the five major capabilities of the program. The reader is referred to AFAPL-TR-78-6, part I, Flexible Rotor Dynamics, (AD-A087 806), for a more detailed discussion of RSVP. This manual also furnishes guidance to the first-time reader in the efficient utilization of the series.

**82-540**

**MAGNA: A Finite Element Program for the Materially and Geometrically Nonlinear Analysis of Three-Dimensional Structures Subjected to Static and Transient Loading**

R.A. Brockman

Research Inst., Dayton Univ., OH, Rept. No. UDR-TR-80-107, AFWAL-TR-80-3152, 512 pp (Jan 1981)

AD-A099 454

**Key Words:** Computer programs, Finite element technique, Structural members, Bars, Membranes (structural members), Plates, Shells

MAGNA is applicable to large structural response problems involving bars, membrane, plates, shells, and three-dimensional solids, experiencing large displacements, finite strains, large rotations, and plastic deformation. The theoretical basis of MAGNA and the numerical procedures employed are described in detail. Several sample analyses are presented to demonstrate the range of capabilities of the program. Instructions are provided for operating the program, modifying storage capacity, preparing input data, estimating computer run times, and interpreting the output. Computer graphics utilities available for the display of input data and analysis results are also described.

**82-541**

**Comparison of NOISEMAP Computer Program with and without the SAE Lateral Attenuation Model**

H. Seidman and R.L. Bennett

Bolt, Beranek and Newman, Inc., Canoga Park, CA, Rept. No. BBN-4533, AFAMRL-TR-81-2, 31 pp (June 1981)

AD-A101 487

**Key Words:** Computer programs, Noise reduction, Aircraft

This study compares the noise contours generated by using the lateral attenuation model presently incorporated in

NOISEMAP and the new SAE attenuation model. Additional studies are recommended in order to directly compare the predicted noise environments using these two different lateral attenuation models with field measured data at elevation angles of zero to 25 degrees.

**82-542**

**PASCO: Structural Panel Analysis and Sizing Code. Capability and Analytical Foundations**

W.J. Stroud and M.S. Anderson

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-80181, 74 pp (Jan 1980)  
N81-27551

**Key Words:** Computer programs, Panels, Stiffened panels

A computer code denoted PASCO which can be used for analyzing and sizing uniaxially stiffened composite panels is described. Buckling and vibration analyses are carried out with a linked plate analysis computer code denoted VIPASA, which is incorporated in PASCO. Sizing is based on nonlinear mathematical programming techniques and employs a computer code denoted CONMIN, also incorporated in PASCO. Design requirements considered are initial buckling, material strength, stiffness, and vibration frequency. The capability of the PASCO computer code and the approach used in the structural analysis and sizing are described.

**82-543**

**Blade Loss Transient Dynamics Analysis, Volume 2. Task 2: Theoretical and Analytical Development. Task 3: Experimental Verification**

V.C. Gallardo, A.S. Storace, E.F. Gaffney, L.J. Bach, and M.J. Stallone

Aircraft Engine Business Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-165373-V-2, R81AEG381-V-2, 250 pp (June 1981)  
N81-27090

**Key Words:** Computer programs, Blade loss dynamics, Turbine blades, Turbine engines

The component element method was used to develop a transient dynamic analysis computer program which is essentially based on modal synthesis combined with a central, finite difference, numerical integration scheme. The methodology leads to a modular or building-block technique that is amenable to computer programming. To verify the analytical

method, turbine engine transient response analysis was applied to two blade-out test vehicles that had been previously instrumented and tested.

**82-544**

**Blade Loss Transient Dynamics Analysis, Volume 3: User's Manual for TETRA Program**

G.R. Black, V.C. Gallardo, A.S. Storace, and F. Sagendorph

Aircraft Engine Business Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-165373-V-3, R81AEG381-V-3, 239 pp (June 1981)  
N81-27091

**Key Words:** Computer programs, Blade loss dynamics, Turbine blades, Turbine engines

The users manual for turbine engine transient response analysis (TETRA) contains program logic, flow charts, error messages, input sheets, modeling instructions, option descriptions, input variable descriptions, and demonstration problems. The process of obtaining a NASTRAN 17.5 generated modal input file for TETRA is also described with a worked sample.

## GENERAL TOPICS

### TUTORIALS AND REVIEWS

(Also see Nos. 520, 521)

**82-545**

**Modern Developments in Wind Engineering: Part 1**

E. Simiu

Center for Building Tech., Natl. Engrg. Lab., Natl. Bureau of Standards, Washington, DC, Engrg. Struc., 3 (4), pp 233-241 (Oct 1981) 1 fig, 4 tables, 67 refs

**Key Words:** Wind-induced excitation, Reviews

The paper presents a review of progress in wind engineering and of unsolved problems that require additional research. The review is divided into three main parts: the wind environment; wind loads and their effects on structures; and structural reliability and serviceability considerations.

82-546

**Modern Developments in Wind Engineering: Part 2**

E. Simiu

Center for Building Tech., Natl. Engrg. Lab., Natl. Bureau of Standards, Washington, DC, Engrg. Struc., 3 (4), pp 242-248 (Oct 1981) 3 figs, 1 table, 110 refs

**Key Words:** Wind-induced excitation, Reviews

This is the second in a series of review papers devoted to the state-of-the-art in wind engineering. The first paper, consisted of an introduction to the series and a discussion of engineering aspects of the wind environment.

**CRITERIA, STANDARDS, AND SPECIFICATIONS**

82-547

**Earthquake Advisory Services: A Prototype Development Project**

H.J. Lagorio and H. Levin

Center for Planning and Development Research, Univ. of California, Berkeley, CA, Rept. No. CPDR-103180, NSF/RA-800493, 88 pp (Oct 1980) PB81-210825

**Key Words:** Seismic design

Development of the prototype Earthquake Advisory Service (EAS) is reported. The EAS is designed to provide direct technical assistance and written materials to advise people who wish to make informed decisions about earthquake hazard reduction in their residences. It is intended also to be adapted to local conditions by community-based agencies. The EAS prototype involved the testing of early assumptions about program implementation, establishment of a systematic methodology review process, and a review of published information pertinent to the project. It combines the concept of housing advisory services and traditional consulting engineering services with self-help or contracted construction.

**BIBLIOGRAPHIES**

82-548

**Tracked Air Cushion Vehicles and Magnetic Levitation. 1964 - June, 1981 (Citations from the NTIS Data Base)**

NTIS, Springfield, VA, Rept. for 1964 - June 1981, 157 pp (Aug 1981)

PB81-807687

**Key Words:** Bibliographies, Ground effect machines, Magnetic vehicle suspensions

The feasibility, design, and track dynamics of tracked air cushioned and magnetically levitated vehicles are investigated in these Government-sponsored research reports. This updated bibliography contains 148 citations, 7 of which are new entries to the previous edition.

82-549

**Tracked Air Cushion Vehicles and Magnetic Levitation. 1976 - June, 1981 (Citations from the Engineering Index Data Base)**

NTIS, Springfield, VA, Rept. for 1976 - June 1981, 160 pp (Aug 1981)

PB81-807695

**Key Words:** Bibliographies, Ground effect machines, Magnetic vehicle suspensions

The feasibility, design, and track dynamics of tracked air cushioned and magnetically levitated vehicles are investigated in these abstracts of reports gathered in a worldwide literature survey. This updated bibliography contains 153 citations, 43 of which are new entries to the previous edition.

82-550

**Industrial Noise Control: Architectural and Environmental Aspects. January, 1975 - August, 1981 (Citations from the International Information Service for the Physics and Engineering Communities Data Base)**

NTIS, Springfield, VA, Rept. for Jan 1975 - Aug 1981, 106 pp

PB81-873705

**Key Words:** Bibliographies, Noise reduction, Industrial facilities, Buildings, Equipment mounts

The architectural and environmental aspects of noise control are discussed in terms of the effect of building standards as well as the proper installation of equipment to reduce vibration of air control equipment. Contains 114 citations fully indexed and including a title list.

**82-551**

**The Dispersion Characteristics of Acoustic Waves as a Function of the Dispersion Media. January, 1975 - June, 1981 (Citations from the International Information Service for the Physics and Engineering Communities Data Base)**

NTIS, Springfield, VA, Rept. for Jan 1975 - June 1981, 124 pp (June 1981)

PB81-870032

**Key Words:** Acoustic waves, Wave diffraction, Bibliographies

The dispersion of acoustic waves in liquids, solids, gases, and polymeric materials is considered. Measurements of temperature and acoustic relaxation mechanisms are included. Special emphasis is placed on very low temperature measurements in liquid inert gas media. Contains 110 citations fully indexed and including a title list.

**82-552**

**Aerodynamic Forces on Motor Vehicles. 1964 - May 1981 (Citations from the NTIS Data Base)**

NTIS, Springfield, VA, Rept. for 1964 - May 1981, 99 pp (June 1981)

PB81-806739

**Key Words:** Bibliographies, Aerodynamic loads, Motor vehicles

Aerodynamic lift, drag, and side forces exerted on moving motor vehicles are investigated in these Government-sponsored research reports. Forces acting on passing vehicles as well as those acting under and around individual moving vehicles are reviewed. This updated bibliography contains 91 citations, 15 of which are new entries to the previous edition.

**82-553**

**Aerodynamic Forces on Motor Vehicles, 1970 - May 1981 (Citations from the Engineering Index Data Base)**

NTIS, Springfield, VA, Rept. for 1970 - May 1981, 154 pp (June 1981)

PB81-806747

**Key Words:** Bibliographies, Aerodynamic loads, Motor vehicles

Aerodynamic lift, drag and side forces exerted on moving motor vehicles are investigated in these reports gathered from worldwide literature surveys. Forces acting on passing vehicles as well as those acting under and around individual moving vehicles are reviewed. Methods for streamlining vehicle configurations for fuel conservation are suggested. This updated bibliography contains 146 citations, 21 of which are new entries to the previous edition.

## USEFUL APPLICATIONS

**82-554**

**Designing Bulk Solids Handling Systems: III. Vibratory Flow Aids**

H. Colijn

H. Colijn & Associates, Monroeville, PA, Plant Engrg., 35 (21), pp 161-164 (Oct 15, 1981) 5 figs

**Key Words:** Materials handling equipment, Vibratory techniques

Two major categories of vibratory flow-promoting devices for consistent discharge of bulk solids from storage bins, silos and hoppers are described. They are the bin vibrators and bin-bottom activators. The selection factors and advantages and disadvantages of all types in each category are discussed.

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White, T.D. ....	282	Wu, S.M. ....	268	Zarkades, A. ....	480

# CALENDAR

## MARCH 1982

- 29-Apr 1 Design Engineering Conference and Show [ASME] Chicago, IL (ASME Hqs.)
- 30-Apr 1 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Oak Brook, IL (Ronald L. Eshleman, Director, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

## APRIL 1982

- 14-16 Fatigue Conference and Exposition [SAE] Dearborn, MI (SAE Hqs.)
- 18-22 Gas Turbine Conference and Products Show [ASME] London, England (ASME Hqs.)
- 19-21 77th Annual Meeting of the Seismological Society of America [SSA] Anaheim, CA (SSA, 2620 Telegraph Ave., Berkeley, CA 94704 - (415) 848-0954)
- 20-22 Mechanical Failures Prevention Group 35th Symposium [National Bureau of Standards] Gaithersburg, MD (Dr. James G. Early, National Bureau of Standards, Bldg. 223/Room A-113, Washington, DC 20234 - (301) 921-2976)
- 20-23 Institute of Environmental Sciences' 28th Annual Technical Meeting [IES] Atlanta, GA (IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)
- 22-23 13th Annual Pittsburgh Conference on Modeling and Simulation [School of Engineering, Univ. of Pittsburgh] Pittsburgh, PA (William G. Vogt or Marlin H. Mickle, Modeling and Simulation Conf., 348 Benedum Engrg. Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)
- 26-30 Acoustical Society of America, Spring Meeting [ASA] Chicago, IL (ASA Hqs.)

## MAY 1982

- 12-14 Pan American Congress on Productivity [SAE] Mexico City (SAE Hqs.)
- 24-26 Commuter Aircraft and Airline Operations Meeting [SAE] Savannah, GA (SAE Hqs.)

## JUNE 1982

- 7-11 Passenger Car Meeting [SAE] Dearborn, MI (SAE Hqs.)

## JULY 1982

- 13-15 'Environmental Engineering Today' Symposium and Exhibition [SEE] London, England (SEECO 82 Organisers, Owles Hall, Buntingford, Herts. SG9 9PL, England - Tel: Royston (0763) 71209)
- 19-21 12th Intersociety Conference on Environmental Systems [SAE] San Diego, CA (SAE Hqs.)

## AUGUST 1982

- 16-19 West Coast International Meeting [SAE] San Francisco, CA (SAE Hqs.)

## SEPTEMBER 1982

- 13-16 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI (SAE Hqs.)

## OCTOBER 1982

- 4-6 Convergence '82 [SAE] Dearborn, MI (SAE Hqs.)
- 4-7 Symposium on Advances and Trends in Structural and Solid Mechanics [George Washington Univ. & NASA Langley Res. Ctr.] Washington, DC (Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Res. Ctr., Hampton, VA 23665 - (804) 827-2897)
- 12-15 Stapp Car Crash Conference [SAE] Ann Arbor, MI (SAE Hqs.)
- 25-28 Aerospace Congress & Exposition [SAE] Anaheim, CA (SAE Hqs.)
- 26-28 53rd Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, DC] Danvers, MA (Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, DC 20375)

## NOVEMBER 1982

- 8-10 International Modal Analysis Conference [Union College] Orlando, Florida (Prof. Raymond Eisenstadt, Union College, Graduate and Continuing Studies, Wells House, 1 Union Ave., Schenectady, NY 12308 - (518) 370-6288)
- 8-12 Acoustical Society of America, Fall Meeting [ASA] Orlando, Florida (ASA Hqs.)
- 8-12 Truck Meeting & Exposition [SAE] Indianapolis, IN (SAE Hqs.)

# CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS:	American Federation of Information Processing Societies 210 Summit Ave., Montvale, NJ 07645	IEEE:	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017
AGMA:	American Gear Manufacturers Association 1330 Mass Ave., N.W. Washington, D.C.	IES:	Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056
AHS:	American Helicopter Society 1325 18 St. N.W. Washington, D.C. 20036	IFTOMM:	International Federation for Theory of Machines and Mechanisms U.S. Council for TMM c/o Univ. Mass., Dept. ME Amherst, MA 01002
AIAA:	American Institute of Aeronautics and Astronautics, 1290 Sixth Ave. New York, NY 10019	INCE:	Institute of Noise Control Engineering P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603
AICHE:	American Institute of Chemical Engineers 345 E. 47th St. New York, NY 10017	ISA:	Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222
AREA:	American Railway Engineering Association 59 E. Van Buren St. Chicago, IL 60605	ONR:	Office of Naval Research Code 40084, Dept. Navy Arlington, VA 22217
ARPA:	Advanced Research Projects Agency	SAE:	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15096
ASA:	Acoustical Society of America 335 E. 45th St. New York, NY 10017	SEE:	Society of Environmental Engineers £ Conduit St. London W1R 9TG, UK
ASCE:	American Society of Civil Engineers 345 E. 45th St. New York, NY 10017	SESA:	Society for Experimental Stress Analysis 21 Bridge Sq. Westport, CT 06880
ASME:	American Society of Mechanical Engineers 345 E. 45th St. New York, NY 10017	SNAME:	Society of Naval Architects and Marine Engineers 74 Trinity Pl. New York, NY 10006
ASNT:	American Society for Nondestructive Testing 914 Chicago Ave. Evanston, IL 60202	SPE:	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203	SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	URSI-USNC:	International Union of Radio Science - U.S. National Committee c/o MIT Lincoln Lab. Lexington, MA 02173
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada		
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan		